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EPA Evaluation of the Automotive Cylinder Deactivator System (ACDS) Under Section 511 of the Motor Vehicle Information and Cost Savings Act

(U.S.) Environmental Protection Agency
Ann Arbor, MI

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EPA Evaluation of the Automotive Cylinder Deactivator System (ACDS) Under Section 511 of the Motor Vehicle Information and Cost Savings Act

by

Edward Anthony Barth

May, 1981

Test and Evaluation Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Environmental Protection Agency

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16. ABSTRACT

This document announces the conclusions of the EPA evaluation of the "Automotive Cylinder Deactivator System" device under [redacted] provisions of section 511 of the Motor Vehicle Information and Cost Savings Act.

On October 2, 1979, the EPA received a request from ACDS, Inc. for evaluation of a fuel saving device termed "Automotive Cylinder Deactivator System (ACDS)." This device is designed to deactivate engine cylinders as a means of increasing a vehicle's fuel economy.

17. KEY WORDS AND DOCUMENT ANALYSIS

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ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 610]

[FRL _____]

FUEL ECONOMY RETROFIT DEVICES

Announcement of Fuel Economy Retrofit Device Evaluation for "Automotive Cylinder Deactivator System"

AGENCY: Environmental Protection Agency (EPA).

ACTION: Notice of Fuel Economy Retrofit Device Evaluation.

SUMMARY: This document announces the conclusions of the EPA evaluation of the "Automotive Cylinder Deactivator System" device under provisions of Section 511 of the Motor Vehicle Information and Cost Savings Act.

BACKGROUND INFORMATION: Section 511(b)(1) and Section 511(c) of the Motor Vehicle Information and Cost Savings Act (15 U.S.C. 2011(b)) requires that:

(b)(1) "Upon application of any manufacturer of a retrofit device (or prototype thereof), upon the request of the Federal Trade Commission pursuant to subsection (a), or upon his own motion, the EPA Administrator shall evaluate, in accordance with rules prescribed under subsection (d), any retrofit device to determine whether the retrofit device increases fuel economy and to determine whether the representations (if any) made with respect to such retrofit devices are accurate."

(c) "The EPA Administrator shall publish in the Federal Register a summary of the results of all tests conducted under this section, together with the EPA Administrator's conclusions as to -

(1) the effect of any retrofit device on fuel economy;

(2) the effect of any such device on emissions of air pollutants; and

(3) any other information which the Administrator determines to be relevant in evaluating such device."

EPA published final regulations establishing procedures for conducting fuel economy retrofit device evaluations on March 23, 1979 [44 FR 17946].

ORIGIN OF REQUEST FOR EVALUATION: On October 2, 1979, the EPA received a request from ACDS, Inc. for evaluation of a fuel saving device termed "Automotive Cylinder Deactivator System (ACDS)". This Device is designed to deactivate engine cylinders as a means of increasing a vehicle's fuel economy.

Availability of Evaluation Report: An evaluation has been made and the results are described completely in a report entitled: "EPA Evaluation of the Automotive Cylinder Deactivator System (ACDS) Under Section 511 of the Motor Vehicle Information and Cost Savings Act," report number EPA-AA-TEB-511-81-7 consisting of 97 pages including all attachments.

EPA also tested the Automotive Cylinder Deactivator System (ACDS) device. The EPA testing is described completely in the report "Emissions and Fuel Economy of the Automotive Cylinder Deactivator System (ACDS)", EPA-AA-TEB-81-7, consisting of 40 pages. This report is contained in the preceding Automotive Cylinder Deactivator System (ACDS) 511 Evaluation as an attachment.

Copies of these reports may be obtained from the National Technical Information Center by using the above report numbers. Address requests to:

National Technical Information Center

U.S. Department of Commerce

Springfield, VA 22161

Phone: Federal Telephone System (FTS) 737-4650

Commercial 703-487-4650

Summary of Evaluation

EPA fully considered all of the information submitted by the Device manufacturer in the Application. The evaluation of the "Automotive Cylinder Deactivator System (ACDS)" device was based on that information and the results of the EPA test program.

Test data submitted by the Applicant did indicate the ACDS system could significantly improve fuel economy. However, the data did not quantify the amount of improvement.

The Applicant did not clearly identify either the device model/ models to be marketed or their design.

The suitability of the ACDS system for engines with valve rocker shafts is unknown. ACDS does claim to have developed hardware for these engines.

The suitability of the ACDS hydraulic cylinder deactivation system is unknown since detailed information on this hardware was not provided.

Installation of the ACDS system would require the skills of a trained mechanic. Activation and deactivation of cylinders (manual system) may require similar skills.

The EPA evaluation of the ACDS system included vehicle testing by the Federal Test Procedure (FTP) urban driving cycle and the Highway Fuel Economy Test (HFET) highway driving cycle. During these tests, measurements were made of the fuel economy (FE) and the emissions of hydrocarbon (HC), carbon monoxide (CO), carbon dioxide (CO_2), and oxides of nitrogen (NOx).

The testing performed by EPA showed:

A. The operation of an 8 cylinder engine on 4 cylinders through the use of the ACDS hardware caused an increase in vehicle CO and NOx emissions to levels exceeding the 1979 standards. FTP CO emissions were typically increased several times to levels near or above the standards. FTP NOx emissions were typically twice the standard. HC emissions were relatively unaffected. These emission increases violate the tampering provisions of the Clean Air Act. (See "F" below).

B. The operation of an 8 cylinder engine on 4 cylinders through the use of the ACDS hardware did improve vehicle fuel economy 5 to 16% for the FTP and 3 to 20% for the HFET for the vehicles tested, but with the associated emission increases described in "A" above.

C. The vehicles tested had poor driveability when using the ACDS to operate an 8 cylinder engine on 4 cylinders.

D. Vehicle acceleration times were substantially increased when the 8 cylinder vehicles were operated with 4 cylinders using ACDS. Acceleration times were typically double the comparable times for 8 cylinder operation.

E. The operation of a vehicle on 4 cylinders caused a serious loss of braking power assist under some driving conditions.

F. Because EPA tests showed that use of this device, on the vehicles tested caused emissions to exceed applicable standards, the installation of this device by a person in the business of servicing, repairing, selling, leasing, or trading motor vehicles, fleet operators, or new car dealers will be considered a violation of section 203(a)(3), the Federal prohibition against tampering with emission control systems. That is, there is currently no reasonable basis for believing that the installation or use of this device will not adversely affect emission performance. This determination does not preclude the use of the ACDS device on a different vehicle or vehicles than those tested by EPA if Federal Test Procedure tests performed on such vehicles clearly establish that emission performance on such vehicles is not adversely affected.

Many state laws prohibit the operation or registration for use on public highways of a motor vehicle on which the emission control device has been removed or rendered inoperative. EPA has concluded that this device will render inoperative an element of design of the emission control devices or systems of a motor vehicle on which it is installed. Therefore, the installation or use of this device by individuals may be prohibited under some state laws.

FOR FURTHER INFORMATION CONTACT: Merrill W. Korth, Emission Control Technology Division, Office of Mobile Source Air Pollution Control, Environmental Protection Agency, 2565 Plymouth Road, Ann Arbor, Michigan 48105, 313-668-4299.

Date

Edward F. Tuerk
Acting Assistant Administrator
for Air, Noise, and Radiation

EPA Evaluation of the "Automotive Cylinder Deactivator System" Under Section 511 of the Motor Vehicle Information and Cost Savings Act

The following is a summary of the information on the Device as supplied by the Applicant and the resulting EPA analysis and conclusions.

1. Marketing Identification of the Device:

ACDS Inc.
Automotive Cylinder De-Activator
"one (1) model for all autos"

2. Identification of Inventor and Patent:

Inventor

Ted Brock
1440 Hill Street
El Cajon, CA 92020

Patent is Attachment A

3. Manufacturer of the Device:

Ambac Fluid Power
511 Glenn Avenue
Wheeling, Illinois 60090

Mathy Machine
429 Vernon Way
El Cajon, CA 92020

4. Manufacturing Organization Principals:

Dennis Duncan - Ambac Fluid Power
Jay Mathy - Mathy Machine

5. Marketing Organization/Applicant:

ACDS Inc.
1440 Hill Street
El Cajon, CA 92020

6. Applying Organization Principals:

Thomas B. Rogers, President
Doug Haugh, Secretary-Treasurer
Donald Mitchell, Vice President Marketing

7. Description of Device: Purpose, Theory, Detailed Description (as supplied by Applicant:

"This de-activator system is designed to stop the combustion on one-half (1/2) of the cylinders of any given engine; therefore increasing

the gas mileage by 45%. The spark plugs keep firing to void the de-activated cylinders of any remaining fuel. By closing all the valves on 1/2 of the cylinders, this automatically stops the fuel flow on one side of the carburetor."

8. Applicability of the Device (as supplied by Applicant):

"This device is applicable to all pushrod style engines, regardless of make, model, year, transmission or ignition. The de-activator is standardized for all cars."

9. Device Installation - Tools and Expertise Required (as supplied by Applicant:

"This device requires the skills of any line mechanic no special tools are required; however we ACDS, provide and insist that anyone involved installing and servicing the product attend our school for one week."

10. Device Operation (as supplied by Applicant):

"See attached Instructions." See Attachment B.

11. Device Maintenance (as supplied by Applicant):

"No maintenance is required. A visual inspection, periodically is recommended - oil level, etc."

12. Effects on Vehicle Emissions (non-regulated) (as supplied by Applicant):

"See attached test sheets." See Attachments C-1 thru C-7.

13. Effects on Vehicle Safety (as supplied by Applicant):

"There are no apparent dangers involved. If the system fails totally, the engine reverts to one-half the cylinders as in normal fuel economy mode."

14. Test Results (Regulated Emissions and Fuel Economy (as supplied by Applicant):

"See attached test sheets. AESI results." See Attachment D.

15. Testing by EPA:

A detailed report of the testing performed by the EPA is given in EPA report, EPA-AA-TEB-81-7, "Emissions and Fuel Economy of the Automotive Cylinder Deactivator System (ACDS)" provided as Attachment B. A brief description of this testing effort is given below:

A. Tests were conducted according to the Federal Test Procedure (FTP) and the Highway Fuel Economy Test Procedure (HFET). The test program consisted of baseline tests and ACDS tests. The ACDS tests

consisted of a standard test procedure (FTP or HFET) in which the vehicles were placed in 4 cylinder operation. The test vehicles were:

(1) A 1979 Chevrolet Impala was tested using the procedures cited in 15A. above. A total of nine FTP's and nine HFET's were used for this evaluation. These test data are detailed in Attachment B.

(2) A 1979 Mercury Capri was tested using the procedures cited in 15A. above. A total of ten FTP's and ten HFET's were used for this evaluation. These test data are detailed in Attachment B.

(3) A 1979 Mercury Cougar was tested using the procedures cited in 15A. above. A total of eight FTP's and eight HFET's were used for this evaluation. These test data are detailed in Attachment B.

B. Steady state cruise tests were conducted to further evaluate the effect of the ACDS device on these vehicles' emissions and fuel economy. Emissions and fuel economy tests were conducted at idle, 25, 35, 45 and 55 mph using the chassis dynamometer. Fuel economy measurements (no emission testing) at the above velocities were also conducted on the road. The test program again consisted of baseline and ACDS tests. For the ACDS tests the vehicles were placed in 4 cylinder operation. The same vehicles cited above were used for this testing.

(1) The 1979 Chevrolet Impala was tested using the procedures cited in 15B. above. A total of fifteen steady state fuel economy and emission tests were conducted on the laboratory dynamometer. A total of ten fuel economy tests were conducted on the road. These test data are detailed in Attachment B.

(2) The 1979 Mercury Capri was tested using the procedures cited in 15B. above. A total of twenty steady state fuel economy and emission tests were conducted on the laboratory dynamometer. A total of sixteen fuel economy tests were conducted on the road. These test data are detailed in Attachment B.

(3) The 1979 Mercury Cougar was tested using the procedures cited in 15B. above. A total of fifteen steady state fuel economy and emission tests were conducted on the laboratory dynamometer. A total of sixteen fuel economy tests were conducted on the road. These test data are detailed in Attachment B.

C. Acceleration tests were conducted on the road and on the chassis dynamometer to evaluate the effect of the ACDS device on vehicle acceleration. For these tests the vehicles were accelerated at wide-open-throttle (0 to 60 mph on chassis dynamometer and 0 to 55 mph on the road). The test program consisted of baseline and ACDS tests. The same vehicles cited above were used:

(1) The 1979 Chevrolet Impala was tested on the chassis dynamometer. A total of five acceleration tests were conducted.

(2) The 1979 Mercury Capri was tested on both the dynamometer and on the road. Five acceleration tests were conducted on the dynamometer and five tests were conducted on the road.

(3) The 1979 Mercury Cougar was tested on both the dynamometer and on the road. Six acceleration tests were conducted on the dynamometer and seven tests were conducted on the road.

16. Analysis

A. Marketing Identification of the Device:

In section 1, ACDS claims there is "... one (1) model for all autos." However, the patent (see Attachment A) and installation instructions (see Attachment B) described different versions of the device. Therefore, EPA requested that ACDS clarify the device's applicability and description (see paragraph 1. and 2. of Attachment E) and ACDS responded (see Attachment F).

(1) The following methods were described for releasing the rocker arm fulcrum:

(a) A hydraulic fulcrum release is described on pages 3 and 4 of the patent and is shown in Figure 2.

(b) A mechanical release of the fulcrum by backing off the nut threaded on the top of the mounting stud that positions the rocker lever (these are existing engine components) is described in the installation manual and installation instructions.

(c) In Attachment E the Applicant states "....the same basic device will apply to rocker shaft engines. The attachment to the engine varies but still can release the fulcrum point of the rocker lever."

(2) The following methods were described for attaching the lifters to the push rods and thereby taking the lifters out of contact with the cam:

(a) Two different means (mechanical and magnetic) of holding the lifters off the cam are described on pages 4 and 5 of the patent.

(b) The unit described in the installation instructions and installation manual shows a still different mechanical means of holding the lifters off the cam.

(3) An alternative system that uses a push rod which tele-

scopes to deactivate valves is described on page 5 of the patent.

(4) In their reply (sections 2 and 3 of Attachment F) ACDS notes there is a manual system kit and a hydraulic kit but does not identify these kits any further.

(5) In the testing conducted by EPA, the mechanical system was used. The kits contained pushrods with the ACDS hardware installed. (See Figures of hardware in Attachment B). However since the Chevrolet and Ford products have different pushrods, the kits were different for the Chevrolet and Mercurys.

(6) Therefore, it is concluded that there are several models instead of the one claimed by the Applicant. These individual models are not identified by the Applicant.

B. Patent

In section 2, ACDS references the Patent. As noted in 16A(2)(a) and 16A(2)(b) the units described in the patent differ from the device described in the installation literature.

C. Description of the Device:

(1) Purpose of the device as stated in the patent (see Attachment A) and application (see Section 7) is to deactivate selected cylinders on a vehicle's internal combustion engine and thereby increase fuel economy.

(2) The theory of operation as stated in the patent (see Attachment A) application (see Section 7) and ACDS November 27, 1979 letter (see Attachment F) is to stop the flow of air and fuel to deactivated cylinders. This is accomplished by "... closing the valves, both intake and exhaust."

(3) Detailed Description of Construction and Operation

(a) As noted in 16A., the documents provided by the Applicant described several methods of embodiment of the concept.

(b) The hydraulic deactivation system/systems to be marketed are not identified. However, the hydraulic deactivation systems detailed in the patent (see Attachment A) are judged to be capable of deactivating valves/cylinders.

(c) The mechanical deactivation system to be marketed is not identified. The system tested by EPA and described in the Installation Instructions, Installation Manual, and EPA report (all three are contained in Attachment B) is judged to be capable of deactivating valves/cylinders on overhead

valve, pushrod engine in which the rocker lever is "... rockingly connected to a mounting stud extending upwardly from the engine head."

(d) These embodiments of the concept, noted in 1(A., add weight/inertia to the engine's valve train in varying degrees. The modification incorporating a piston and cylinder in the pushrod (see Attachment A) would likely add the most weight. The springs attached to the pushrods will also affect valve action. The overall effect of these modifications on valve train action would be most pronounced at high engine rpm. Only activated cylinder operation would be effected.

(i) The effect on valve action of the hydraulic system is unknown.

(ii) The effect on the mechanical system is not completely known. However, no problems related to valve train action were encountered in testing. Therefore, the mechanical system is judged likely to have no adverse affect on valve action. The long term durability of the system and its long term effects on the engine are unknown.

D. Applicability of the Device:

(1) The device is not applicable to all pushrod engines. i.e. one model for all engines

(a) The mechanical systems supplied by EPA for testing contained pushrods with springs and clips attached. The Ford and Chevrolet pushrods were of different lengths. However, a system/kit containing only springs and clips may be applicable to more engines.

(b) The mechanical systems supplied EPA, instructions (see Attachment B), literature (see Attachments G-1, G-2), and ACDS reply to EPA's inquiry (Attachment F) did not show/ provide any means for releasing the rocker arm fulcrum of engines with a rocker shaft.

(c) The hydraulic system described in the patent (Attachment A) differs in the manner of fulcrum release from the mechanical systems. Again, the means of releasing the rocker arm fulcrum of rocker shaft engines is not described.

(2) The device is not applicable to fuel injected engines (gasoline or diesel) because the device provides no means of shutting off the fuel flow to the deactivated cylinders.

(3) The Applicant in the clarification reply to EPA (Attachment F) states:

"We have successfully deactivated the following gasoline overhead valve, pushrod type engines:

1. All six and eight cylinder Chevrolet, inc. V-6.
2. All six and eight cylinder Fords, inc. V-6.
3. All six and eight cylinder Chrysler products.
4. All six and eight cylinder Int. Harvester."

Since several of these engines use rocker shafts, it is presumed the Applicant has been able to successfully design a deactivation systems for rocker shafts. However, EPA has no information by which to judge the suitability of these systems.

(4) In response to EPA's request for information (Attachment E) about the applicability of the hydraulic system to vehicles not equipped with a power steering pump, the Applicant stated:

"Yes, vehicles without power steering can use the device by adding a steering pump or other hydraulic pressure source, such as a 12-volt pump kit."

Assuming a pump is available from the vehicle manufacturer or a suitable 12 volt pump is available, the hydraulic system is judged to be applicable to non-power steering equipped vehicles. The Applicant did not identify a source of suitable 12 volt pumps.

(5) In Attachment F the Applicant refers to the suitability of cylinder deactivation systems being developed for overhead cam, two cycle, and diesel engines. The systems for these types of engines were not described nor were they part of the Applicant's evaluation request.

E. Device Installation - Tools and Expertise Required:

(1) The ACDS instructions (see Attachment B) are judged to be complete for the physical installation of the mechanical deactivation system described in the instructions.

(2) The installation of the ACDS mechanical system appears to be within the skills of line mechanics as claimed.

(3) The tools required for the installation of the ACDS mechanical system are those normally available to a line mechanic.

(4) ACDS, Inc. estimates installation of the manual system would require two hours (see Attachment F). However, during testing conducted at EPA, it took ACDS personnel approximately four to five manhours to install the ACDS mechanical system. EPA personnel, less experienced in the installation, required considerably more time. Since these installations were on vehicles with clean engine compartments and the access holes were not punched in the valve covers, the average installation would probably take longer than 5 manhours.

(5) The Applicant estimates eight hours are required to install the hydraulic cylinder deactivation system. Insufficient information was provided to judge the installation expertise, tools, or time required for installing the hydraulic cylinder deactivation systems.

F. Device Operation:

(1) Manual valve deactivation system

For the Chevrolet:

The instructions referenced in Section 11 (see Attachment B) cover the installation of the ACDS manual system hardware and the procedures for activating and deactivating cylinders when using the mechanical system.

ACDS Inc. stated in their reply to EPA (Attachment F):

> "We now have systems ready to market which are totally manual. You cannot switch from mode to mode while vehicle is moving. You must physically adjust valves into deactivated or normal position. This takes approximately five minutes."

The instructions provided for the Chevrolet V-8 state:

> "To adjust ROCKERS for 8-CYLINDER operation, remove cup plugs in rocker covers, insert socket wrench, MAKING SURE cam lobe is DOWN. (This is most easily done by removing ignition distributor cap, and turning engine over until rotor points at spark plug wire location for that cylinder.) Then adjust as with a STOCK engine. Turn down adjustment nut until there is zero clearance. (Make sure you are not depressing lifter.) Advance nut 1/2 turn. This is the running adjustment."

Typical Chevrolet valve adjustment requires "... backing off the adjusting nut (rocker arm stud nut) until there is play in the push rod and then tighten nut to just remove all push rod clearance. This may be determined by rotating push rod with fingers as the nut is tightened. When push rod does not readily move in relation to the rocker arm, the clearance has been eliminated. The adjusting nut should then be tightened an additional 1 turn to place the hydraulic lifter plunger in the center of its travel. No other adjustment is required."

The cup plugs provided with the ACDS manual kit do permit ready access to the adjusting nut. However, the Chevrolet engine's push rods are inaccessible unless the valve cover is removed. Also, adjustment of the lifters to obtain ACDS's recommended clearance, see 16G(2)(b), requires valve cover removal. Therefore, for Chevrolets, to activate the deactivated cylinders requires removal of the valve covers.

With the valve cover removal, rotation of engine, adjustment of the valve lifters, the Chevrolet would take closer to an hour and may require valve cover gasket replacement plus mechanical skills.

However, deactivation of cylinders (i.e. 8 cylinder to 4 cylinder operation) is a considerably simpler procedure. It would not require valve cover removal or precise setting of the valve lifters. Therefore, deactivating cylinders (i.e. 8 cylinder to 4 cylinder operation) would take approximately 15 minutes.

For Ford products:

The typical Mercury adjustment requires torquing the adjustment nut (rocker arm stud nut). Therefore for Ford products the cup plugs would permit ready access to activate the deactivated cylinders. Like the Chevrolet, the cam lobe must be down for this procedure. However, the adjustment of lifters to obtain ACDS's recommended clearance, see 16G(2)(b), requires valve cover removal.

Again with the valve cover removal, rotation of engine, adjustment of the valve lifters, the reactivation of cylinders (i.e. from 4 cylinder operation to 8 cylinder operation) would require at least an hour, may require valve cover gasket replacement, and will require mechanical skills. Valve deactivation would take approximately 15 minutes.

Alternative operating procedures:

During the testing conducted by EPA, ACDS personnel recommended and used a different procedure to activate and deactivate the cylinders. After the vehicle was set to manufacturer's specifications:

(i) To deactivate cylinders the adjusting nuts were backed off exactly six turns.

(ii) To activate the deactivated cylinders, the adjusting nuts were tightened exactly six turns.

(iii) These procedures each required about 15 minutes.

(iv) If the required information is available, a modification of the procedures used by ACDS Inc. at EPA may be considerably quicker than the preceeding listed for Chevrolet and Ford products. However, any error in adjustment could mean reverting to the longer procedures noted above.

ACDS Inc. did not specify who should perform the in-use activation and deactivation of the cylinders. The ACDS Inc. statement in 16F(1) might also be construed to mean that conversion back and forth (i.e. 8 cylinder to 4 cylinder and back to 8 cylinder operation) is readily

performed by a reasonably handy vehicle operator. However, the mechanical skills, tools, and time required to switch operating modes would severely limit the number of operators who would be able to activate/deactivate cylinders as driving needs changed.

(2) Hydraulic valve deactivation system

Since the information provided in the application gave no guidance to the users of the hydraulic system, EPA requested clarification "should it only be used in highway driving or does its usage include city driving? How are the control valves activated." (See Attachment E.) ACDS Inc. replied that there were "No restrictions on use. The control valves are activated by the operator." (See Attachment F.)

(a) ACDS Inc. also stated in their reply (Attachment F):

"As to control of these devices, we have leaned toward an inexpensive type control, such as a switch convenient to the operator; however, since the system is electric over hydraulic, automatic control presents no problems beyond current technology."

(b) Since details of the control valve, switch, or automatic control were not provided, EPA is unable to assess the suitability of the control techniques for the hydraulic deactivation system.

G. Device Maintenance:

In section 11 the Applicant stated "No maintenance is required. A visual inspection, periodically is recommended - oil level, etc."

In the clarifying letter, Attachment F, the Applicant stated:

(a) "Solid lifter settings - factory specifications."

(b) "Hydraulic lifters - set to .002 clearance on deactivated cylinders. Hydraulic lifters have not failed in any way with this revised setting. We recommend a valve adjustment period compatible with a solid lifter application. The reason we alter this adjustment on hydraulic lifters is to prevent a rough running condition on the deactivated to the activated mode momentarily while the hydraulic lifter self adjusts to zero clearance."

Note: Obtaining this clearance may require removal of the valve cover on all vehicles with hydraulic lifters.

The Applicant's maintenance statements are judged to be true for the mechanical system. Since a detailed description of the hydraulic system was not provided, EPA cannot fully evaluate its maintenance requirements. However, the requirement for minimal maintenance is judged to be also likely for the hydraulic system.

H. Effects on Vehicle Emissions (non-regulated):

(1) The data supplied by the Applicant (Attachments C-1 thru C-7) only pertains to fuel economy.

(2) Non-regulated emissions were not assessed as part of this evaluation. However, since the Device does not mechanically modify the vehicle's emission control system, it appears reasonable to assume that the Device would not significantly affect a vehicle's non-regulated emissions.

I. Effects on Vehicle Safety and Operation:

(1) Safety

(a) The Applicant's statement in Section 13 apparently apply to the hydraulic system. Insofar as this statement applies to the immediate effect of a hydraulic system failure, the statement appears to be true. The manual system would not experience a similar failure mode.

(b) During EPA's testing of the Device, several serious safety problems were encountered.

(i) During the road tests, braking problems were encountered with the Impala. At times there was no braking power assist when the vehicle was operated with 4 cylinders deactivated. The source of this problem was the low manifold vacuum available during most of the operation on 4 cylinders. Therefore, a repeated series of accelerations and braking could reduce the power brake's vacuum reservior supply to levels that are unable to provide power brake assist. This could readily occur in heavy slow speed traffic or when highway cruising is followed immediately by a series of brake applications. This problem was further aggravated when the air conditioning was on, since the air conditioner caused the loss of an additional 2-4 inches of vacuum. This braking problem was not encountered with the other two vehicles, however, they were not driven in similar heavy traffic conditions and it is, therefore, not known if they too are susceptible to this braking problem.

(ii) Although the vehicles accelerated much slower on 4 cylinders, once a cruise speed was achieved, the vehicles decelerated slowly when the driver's foot was removed from the accelerator. Therefore, there was negligible engine braking.

(iii) When converted to 4 cylinders, the vehicle's idle speed (neutral) typically increased several hundred rpm. However, as soon as the vehicle was placed in gear, idle speed dropped below normal 8 cylinder idle (drive) speed and

the vehicles had a tendency to stall, especially if the air conditioner was on. Engine idle (drive) speeds were not readjusted since such readjustment was not part of the ACDS installation/operating procedures.

(iv) 0-55 mph acceleration times ranged from 20 to 27 seconds when the vehicles were operated on one half the cylinders (8 cylinder 0-55 mph acceleration times were between 10 and 13 seconds). At speeds above 30 mph, the vehicle could not accelerate faster than 2 mph/sec with cylinders deactivated. This may be unsafe for some driving conditions. The hydraulic system, if controlled by the driver, may alleviate this problem.

(c) The Applicant claims the device is applicable to all 4, 6, and 8 cylinder pushrod engines. Acceleration capability was marginal for the V-8's tested. Many of the 4 and 6 cylinder vehicles would not have sufficient power when half the cylinders are deactivated.

(2) Operation

(a) When accelerating with only 4 cylinders operating, the Impala's engine vacuum provided insufficient vacuum to the air conditioner control system. This lack of vacuum caused the air conditioner control system air valves to partially shut and thus greatly reduced the cool air flow when accelerating. The two Mercury's were not checked to see if a similar problem occurred.

(b) When cranking the vehicles (4 cylinder operation) the starter would momentarily stop due to the loads imposed by the 4 deactivated cylinders. This problem was more prevalent for warm engines. A limited check indicated peak starting currents were twice as high as normal. This indicates that there may be starting problems for vehicles with weak batteries or starting systems.

J. Test Results Supplied by Applicant:

Applicant did not submit any test data per the Federal Test Procedure however, the Applicant did submit test data per the Highway Fuel Economy Test[1]. The requirement for test data following these procedures is stated in the Application Format EPA sends to potential Applicants. The test data submitted by the Applicant are listed below and evaluated.

(1) Two Highway Fuel Economy Tests (HFET) were performed on one vehicle - one test on four cylinders (17.4 mpg), one test on eight cylinders (11.8 mpg). Although this pair of tests showed a large improvement in fuel economy when four cylinders were deactivated, EPA noted the eight cylinder fuel economy results were quite low and requested additional information (see Attachment E) for the test vehicle.

(a) ACDS Inc. stated:

"The vehicle was dyno-tuned at an outside tune-up facility. The Highway Fuel Economy Test numbers for the eight cylinder engine testing are compatible with the history previous to any modification. We do not have any rationale to explain this."

(b) The similar 49 state vehicle certified by EPA gave 13 mpg city and 17 mpg highway. The California vehicle gave 12 mpg city and 18 mpg highway. (1978 Gas Mileage Guide, second edition, February 1978).

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(1) From EPA 511 Application Format:
Tests Results (Regulated Emissions and Fuel Economy):
Provide all test information which is available on effects of the device on vehicle emissions and fuel economy.

The Federal Test Procedure (40 CFR Part 86) is the only test which is recognized by the U.S. Environmental Protection Agency for the evaluation of vehicle emissions. The Federal Test Procedure and the Highway Fuel Economy Test (40 CFR Part 600) are the only tests which are normally recognized by the U.S. EPA for evaluating vehicle fuel economy. Data which have been collected in accordance with other standardized fuel economy measuring procedures (e.g. Society of Automotive Engineers) are acceptable as supplemental data to the Federal Test Procedure and the Highway Fuel Economy Data and will be used, if provided, in the preliminary evaluation of the device. Data are required from the test vehicle(s) in both baseline (all parameters set to manufacturer's specifications) and modified forms (with device installed).

(c) The vehicle's HFET CO emissions were quite high, 37.2 gm/mile, when operating on eight cylinders. This is very high for the HFET test. A similar vehicle was certified at less than 15.0 grams per mile for the FTP. A vehicle meeting this standard, typically emits less than 0.2 grams per mile for the HFET.

(d) The relatively poor fuel economy and high CO emissions for this vehicle (eight cylinder operation) suggest that this was not a representative vehicle.

(2) EPA noted that the Applicant had tested another vehicle (see Attachment D) and therefore requested these test data on the device.

(a) ACDS Inc. replied (see Attachment F)

> "The Cadillac referred to in the letter was a brand new car. We understand that a car not broken in does not constitute a reliable test. While the car did show gains in the tests conducted on it, they were not up to the standard of the gains that we had experienced on a wide variety of road testing, both city and highway. Under the above circumstances we do not desire to submit test data."

(b). As noted in note of 16J., EPA requires Applicant to "provide all test information which is available on the effects of the device on vehicle emissions and fuel economy." The Applicant is not permitted to pick and choose data for submission.

(c) Therefore, the Applicant's reply is judged to be non-responsive.

(3) Seven test summaries were submitted with the application. Some of these tests do show an improvement in fuel economy. These represent relatively uncontrolled tests and therefore cannot be used to quantify the improvement in fuel economy. However, due to the relatively large percentage improvements in fuel economy shown, these tests do suggest the ACDS device does improve vehicle fuel economy. These results are discussed below:

(a) Attachment C-1 gives tests stock, 14.4 mpg; with ACDS, 21.6 mpg; and with ACDS and a turbocharger, 26.3 mpg. Test distances are long enough to verify the improvements in fuel economy. The data does show an improvement in fuel economy. However, since testing occurred under uncontrolled conditions (driving, terrain, weather, fuel, etc.), the exact percentage improvement cannot be quantified.

(b) Attachment C-2 shows ACDS fuel economy only. No comparison baseline fuel economy is given.

(c) Attachment C-3 shows ACDS fuel economy only. No comparison baseline fuel economy is given.

(d) Attachment C-4 quotes a percentage improvement for a Diesel. No data are given.

(e) Attachment C-5 is data on Ford discussed in 16J(1).

(f) Attachment C-6 is a letter summarizing a trip with the ACDS. Apparently this is the same Ford discussed in 16J(1).

(g) Attachment C-7 is test program on Ford discussed in 16J(1). Again relatively uncontrolled tests. Note testing with 8 cylinders (8/23 to 8/25), 12.7 mpg; 4 cylinders (8/27 to 9/1), 13.3 mpg; and both 8 and 4 cylinders (9/1 to 9/3) 13.0 mpg are nearly identical. Certainly within the 1-2 gallon variation quoted for topping off the fuel tank.

(4) In their reply, Attachment F, ACDS states:

"Since testing the vehicles at AESI, we have come to realize that due to the fact the tests were designed with the eight cylinder engine and all of the performance curves were based on the eight-cylinder power in relation to that particular vehicle, we cannot possibly receive a fair test under these conditions. We do not claim that the vehicle will perform on half its cylinders in any given situation as well as it does on full power. Our goal is to save fuel and we have found that people will modify their driving habits to accomplish this with the deactivated engine. We strongly feel that a modified test curve should be designed around the deactivated mode of the vehicle."

The FTP and HFET tests were not designed for large V-8 vehicles. Small displacement six and eight cylinder vehicles were used in the development of the test procedures. Fours, sixes, and eights are routinely tested using these test procedures. Most of these vehicles are able to follow the driving schedule.

The procedures cover vehicles unable to follow the driving schedule.

K. Test Results Obtained by EPA:

The tests conducted by EPA are discussed in detail in Attachment B, therefore a duplicate presentation is not provided.

17. Conclusions

A. The testing performed by EPA showed:

(1) The operation of a vehicle on 4 cylinders through the use of the ACDS hardware did cause a substantial increase in vehicle emissions to levels exceeding the applicable 1979 standards (HC 1.5 gm/mi, CO 15.0 gm/mi, NOx 2.0 gm/mi). CO emissions were typically increased several times to levels near or above the standards. NOx emissions were typically twice the standard. These emission increases violate the tampering provisions of the Clean Air Act (see "G" below).

(2) The operation of a vehicle on 4 cylinders through the use of the ACDS hardware did improve vehicle fuel economy 5 to 16% for the FTP and 3 to 20% for the HFET for those 8 cylinder vehicles tested, but with the associated emission increases described in (1) above.

(3) The vehicles had poor driveability when using the ACDS to operate on 4 cylinders.

(4) Vehicle acceleration times were substantially increased when the vehices were operated with 4 cylinders using ACDS. Acceleration times were typically double the comparable times for 8 cylinder operation.

(5) The operation of a vehicle on 4 cylinders caused a serious loss of braking power assist under some driving conditions.

B. Test data submitted by the Applicant did indicate the ACDS system could significantly improve fuel economy. However, the data did not quantify the amount of improvement.

C. The Applicant did not clearly identify the device model/models to be marketed and their design.

D. The suitability of the ACDS system for engines with valve rocker shafts is unknown. ACDS does claim to have developed hardware for such engines.

E. The suitability of the ACDS hydraulic cylinder deactivation system is unknown since detailed information on this hardware was not provided.

F. Installation of the ACDS system would require the skills of a line mechanic. Activation and deactivation of cylinders (manual system) may require similar skills.

G. Because EPA tests showed that use of this device, on the vehicles tested caused emissions to exceed applicable standards, the installation of this device by a person in the business of servicing, repairing, selling, leasing, or trading motor vehicles, fleet operators, or new car dealers will be considered a violation of section 203(a)(3), the Federal prohibition against tampering with emission control systems. That is, there is currently no reasonable basis for believing that the installation or use of this device will

not adversely affect emission performance. This determination does not preclude the use of the ACDS device on a different vehicle or vehicles than those tested by EPA if Federal Test Procedure tests performed on such vehicles clearly establish that emission performance on such vehicles is not adversely affected.

Many state laws prohibit the operation or registration for use on public highways of a motor vehicle on which the emission control device has been removed or rendered inoperative. EPA has concluded that this device will render inoperative an element of design of the emission control devices or systems of a motor vehicle on which it is installed. Therefore, the installation or use of this device by individuals may be prohibited under some state laws.

List of Attachments

Attachment A	Cylinder Deactivator System, Patent 4,169,449 (provided with 511 Application)
Attachment B	TEB Report EPA-AA-TEB-81-7, "Emissons and Fuel Economy of the Automotive Cylinder Deactivation System (ACDS)"
Attachments C-1 thru C-7	ACDS test data (provided with 511 Application)
Attachment D	AESI test results (provided with 511 Application)
Attachment E	Copy of EPA October 31, 1979 letter requesting clarification of information submitted in 511 Application
Attachment F	Copy of ACDS November 27, 1979 letter from Tom Rogers to Charles L. Gray responding to EPA October 31, 1979 letter
Attachments G-1, G-2	ACDS sales literature (provided with 511 Application)
Installation Instructions	For GM V-8 Provided with 511 Application, copy incorporated in Attachment B
Installation Manual	For Chevrolets Provided with 511 Application, copy incorporated in Attachment B

Attachment A

United States Patent [19]

Brock, Jr.

[11] **4,169,449**

[45] **Oct. 2, 1979**

[54] **CYLINDER DE-ACTIVATOR SYSTEM**

[76] Inventor: **Horace T. Brock, Jr., Box 238, Ehrenberg, Ariz. 85334**

[21] Appl. No.: **848,937**

[22] Filed: **Nov. 7, 1977**

[51] **Int. Cl.**[2] **F02D 13/06**

[52] **U.S. Cl.** ..... **123/198 F; 123/90.43**

[58] **Field of Search** ..... 123/198 F, 90.43, 90.46, 123/90.63, 90.12, 90.13

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,948,274	8/1960	Wood	123/198 F
3,964,455	6/1976	Brown	123/90.43
4,050,435	9/1977	Fuller, Jr. et al.	123/198 F
4,061,123	12/1977	Janes	123/198 F
4,064,861	12/1977	Schulz	123/198 F
4,114,588	9/1978	Jordan	123/198 F

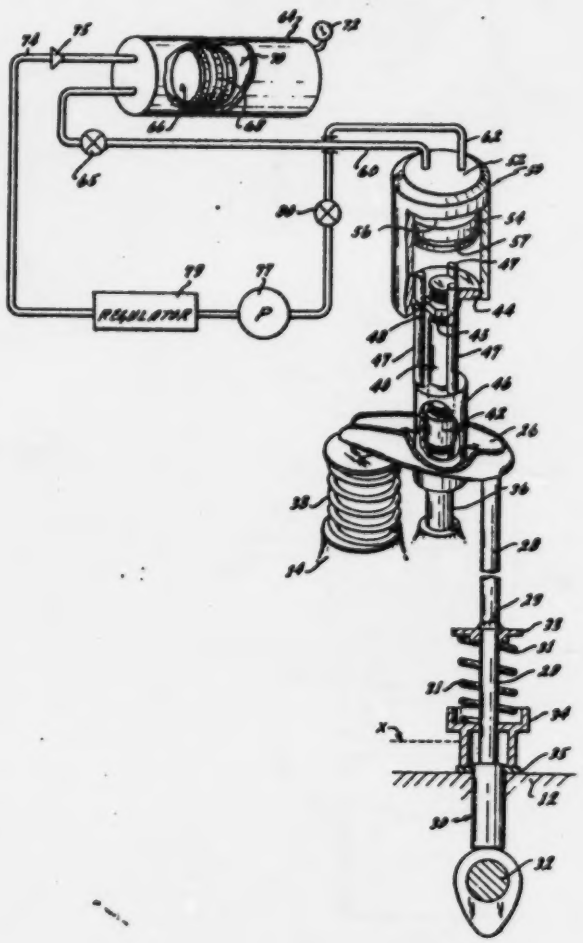
Primary Examiner—Ira S. Lazarus

Attorney, Agent, or Firm—Charles C. Logan, II

[57] **ABSTRACT**

A cylinder de-activator system for an internal combustion engine having a block, an engine head, a plurality of engine cylinders in the block, intake and exhaust valves for each engine cylinder spring-loaded to their closed positions, a cam operated valve train operating each of the valves with the valve train having a rocker lever that is rockingly connected to a mounting stud extending upwardly from the engine head, and hydraulic means for varying the fulcrum position on the mounting studs about which the rocker lever rocks.

6 Claims, 5 Drawing Figures



U.S. Patent Oct. 2, 1979 Sheet 1 of 2 4,169,449

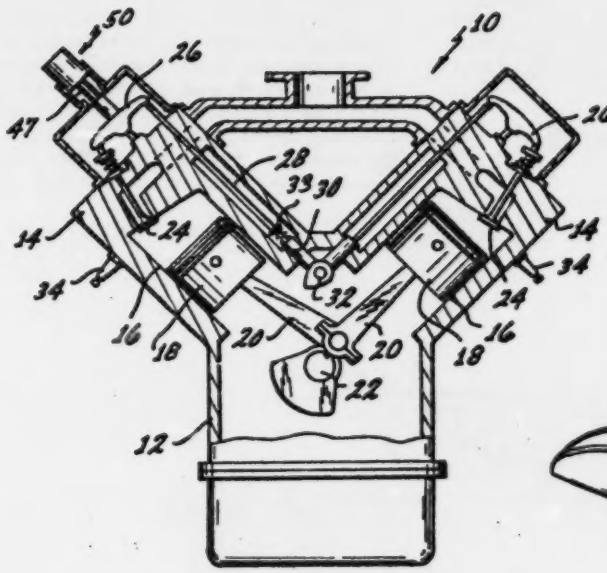


Fig. 1

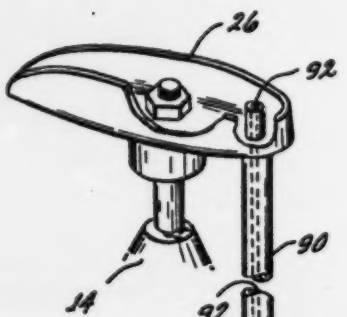


Fig. 4

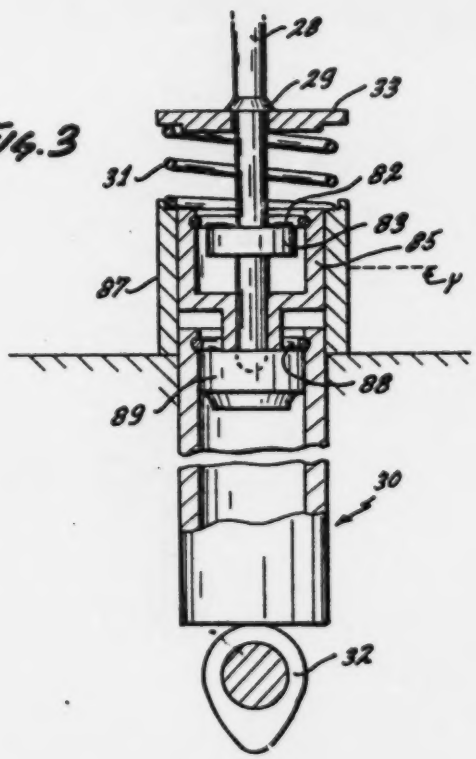
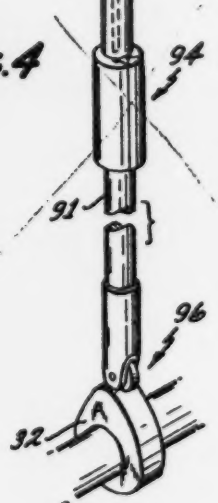


Fig. 3



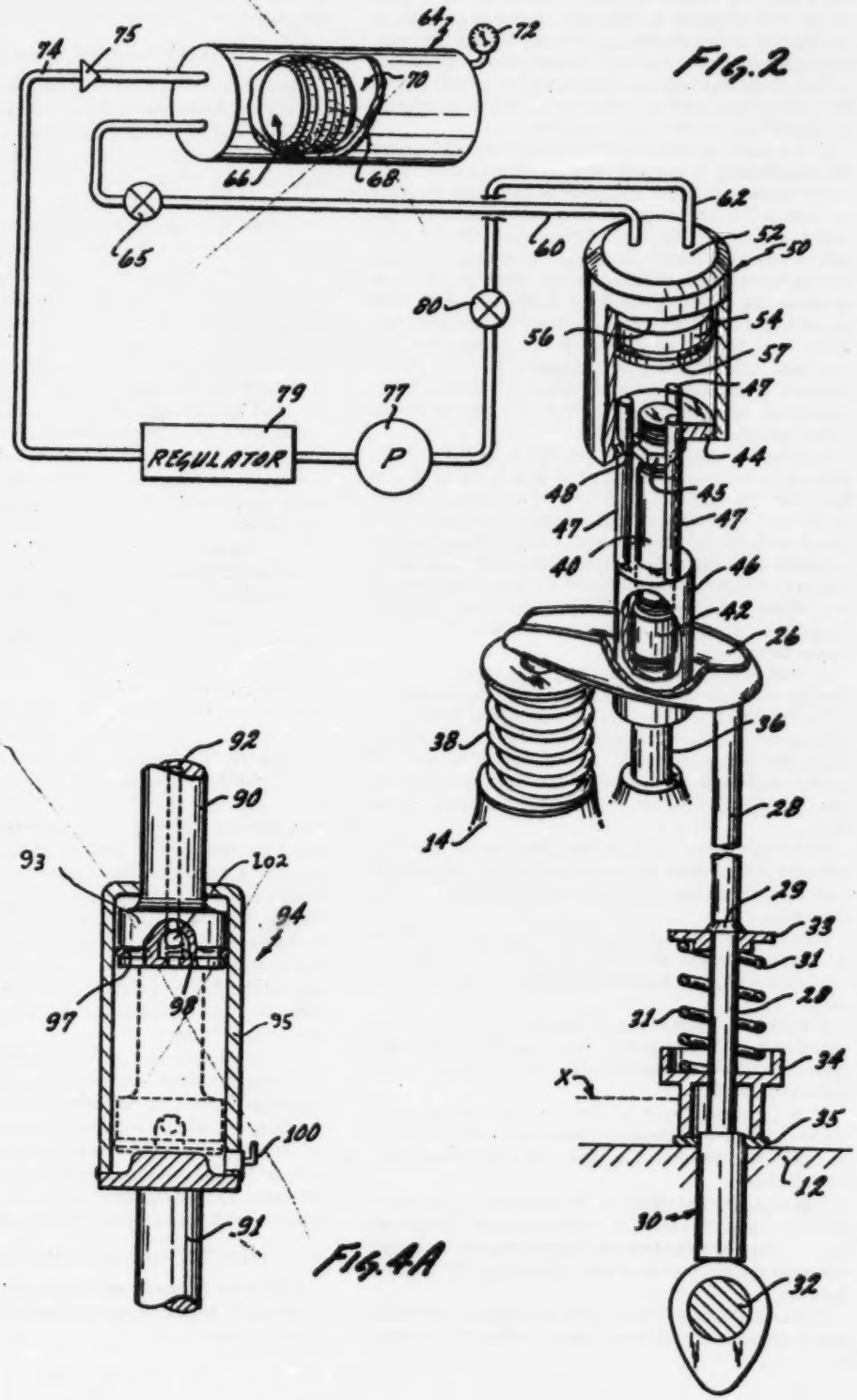

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Fig. 2

92
90
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102
94
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98
95
100
91

Fig. 4A

CYLINDER DE-ACTIVATOR SYSTEM

BACKGROUND OF THE INVENTION

The invention relates to a multi-cylinder internal combustion engine and in particular, to means for making a selected number of the cylinders of the engine inoperative whereby to cause the engine to operate on less than all of its cylinders, and thusly change the operating characteristics and fuel consumption of the engine so that it will operate at a fraction of its power output and at a corresponding reduction in fuel consumption whenever full power is not required.

In the past, several inventions have been developed for inactivating a selected number of cylinders of an engine during different stages of its operation in order to reduce fuel consumption. One such device is illustrated in U.S. Pat. No. 2,197,529, wherein the inventor utilizes two inlet manifolds. Certain of the cylinders are connected to one manifold and the others to the other manifold. By arresting the flow of fuel into one of the manifolds, while delivery is continued to the other manifold, half of the cylinders of the engine are deactivated, thus resulting in a conservation of fuel; for instance, in an automobile that stops at frequent intervals while permitting the engine to run idly while the driver attends to some errands.

Another device for inactivating predetermined cylinders of an internal combustion engine is illustrated in U.S. Pat. No. 2,528,983. In this system, each of the intake and exhaust valves have a plurality of cams with which each may be brought into contact. Depending on which of these cams the bottom of the valve comes into contact with, determines whether the valve will open or not. These cams are moved by shifting the camshaft laterally to change the operation of the exhaust and intake valves.

A third system for de-activating predetermined cylinders of an internal combustion engine is illustrated in U.S. Pat. No. 2,948,274. In this device, the desired results are effected by locking the valve lifter mechanism of the exhaust valve of each said selected cylinder out of operation after the exhaust valve has been opened. Normal operation is resumed by releasing the locked valve lifters.

Numerous other attempts have been made to devise cylinder de-activator systems for internal combustion engines but most have not been successfully received by the public.

It is an object of the invention to provide a cylinder de-activator system that may be retrofitted to internal combustion engines presently in operation on the highways.

It is also an object of the invention to provide a novel cylinder de-activator system that may be installed on a typical internal combustion engine by changing as few parts as possible.

It is a further object of the invention to provide a novel cylinder de-activator system that can be adapted to a typical internal combustion engine by a do-it-yourself mechanic.

It is an additional object of the invention to provide a novel cylinder de-activator system that can de-activate any number of cylinders on a given engine by simply stopping the air/fuel flow and exhaust gas flow in that cylinder.

It is an additional object of the invention to provide a novel cylinder de-activator system which immobilizes the normal up and down reciprocal motion of the push rod.

It is an additional object of the invention to provide a novel cylinder de-activator system using a hydraulic method of de-activating the valves, thereby attaining a cushion effect which causes less mechanical shock on the the valve train than a strictly mechanical mechanism when reactivating the valve at high speeds.

SUMMARY OF THE INVENTION

The cylinder de-activator system is to be utilized with an internal combustion engine having a block, an engine head, a plurality of engine cylinders in the block, intake and exhaust valves for each cylinder spring loaded to their closed positions, and a cam operated valve train operating each of the valves by utilizing a rocker lever having an aperture in its mid-section that allows the rocker lever to be rockingly connected to a mounting stud extending upwardly from the engine head. When the engine is in its normal operating condition, a nut threaded on the top of the mounting stud is tightened down to its proper degree thereby setting the fulcrum of the rocker lever at its proper position to open the valves in response to the upward reciprocating motion of the push rod against one end of the rocker lever.

The novel cylinder de-activator system is relatively easy to install on the tape of internal combustion engine just described. First the nut is threaded off the top of the mounting stud of each of the intake and exhaust valves that are to be de-activated. This then frees the push rods so that they may be removed to allow their bottom ends to be modified in one of the manners described in the description of the preferred embodiments that follows later on in the specification. After the modified push rod has been reinserted into position, the remaining modifications take place entirely above the rocker lever. A hydraulic assembly is attached to the top of the rocker lever above the mounting stud that allows the fulcrum of the rocker lever to be changed by means of hydraulic pressure directed against the top of the rocker lever. The hydraulic assembly has a source of hydraulic fluid under pressure connected to it and also a means for releasing the hydraulic fluid pressure from within the hydraulic assembly. The source of hydraulic fluid under pressure may be the power steering pump of the automobile or an auxiliary pump. A pressure accumulator may be utilized in the system to provide a source of hydraulic fluid under pressure at the time the automobile engine is started, thus eliminating a delay period that would be normal if it were necessary to build up pressure prior to activating any of the previously deactivated cylinders.

Control valves in the fluid circuits of the cylinder de-activator system may be manually, mechanically, or electrically operated either by controls mounted under the hood of the automobile or mounted on the dash inside of the automobile. It is also possible to set up the system so that each individual cylinder may be deactivated separately, or a bank of cylinders may be deactivated by a single set of controls.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation view of the type of internal combustion engine being modified with portions shown in cross section;

FIG. 2 is a schematic illustration of the cylinder de-activator system showing how it is attached to the exhaust and intake valve train;

FIG. 3 illustrates an alternative structure that may be attached to the bottom of the push rods;

FIG. 4 schematically illustrates an alternative system for de-activating the exhaust and intake valve trains; and

FIG. 4*a* is an enlarged cross sectional view of the push rod assembly utilized in the embodiment illustrated in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The operation of the cylinder de-activator system for an internal combustion engine can best be described by referring to the drawings. In FIG. 1, a typical V-8 engine of the type to which applicant's system can be applied is illustrated. The engine is generally designated numeral 10. It has a block 12 and a pair of engine heads 14. In the conventional cylinders 16 are pistons 18 on connecting rods 20 coupled to a crankshaft 22. Valves 24 are operated through rocker levers 26 by push rods 28, which are actuated through valve lifters 30 by cam shaft 32. Spark plugs 34 are located with their tips extending into the top of the cylinders 16.

The manner in which the above described internal combustion engine is modified by applicant's invention is clearly illustrated in FIG. 2. Extending upwardly from the top of the engine head 14 is a mounting stud 36. Rocker lever 26 has an aperture in its mid-section that allows the rocker lever to be rockingly connected to the mounting stud 36. One end of the rocker lever presses against coil spring 38 that normally keeps the valve 24 closed. The other end of the rocker lever receives the top of push rod 28. The engine normally would have a nut screwed down on the top of mounting stud 36 that is torqued to the proper amount to provide a fulcrum for the rocker lever to rock about when push rod 28 is pushed upwardly by the cam on cam shaft 32. This action causes the rocker lever to compress coil spring 38 and in turn open valve 24. To this basic structure applicant adds his cylinder de-activator system which uses hydraulic means for varying the fulcrum position. By raising the fulcrum position of the rocker lever on the mounting stud a sufficient height, the operation of the intake and exhaust valves 24 is inactivated.

The hydraulic means for varying the fulcrum position of rocker lever 26 will now be described. A second mounting stud is coupled at its lower end to the top of mounting stud 36 by coupling 22. The top end of mounting stud 40 is threaded into a threaded bore in mounting plug 44 that closes the lower end of hydraulic cylinder 50. A sleeve 46 surrounds the mounting stud 36 with its lower end in contact with the top of rocker lever 26. In some instances a ball washer might be inserted between the bottom of sleeve 46 and rocker lever 26 or a similar type structure might be formed on the bottom of sleeve 46. A plurality of force transfer pins 47 have their bottom surface supported by the wall thickness of the top of sleeve 46 that forms a force transfer surface and their upper ends pass through a plurality of bores 48 in the mounting plug 44. These pins 47 move freely in the bores. The height of the hydraulic cylinder above the sleeve 46 can be varied by screwing the top end of mounting stud 40 varying distances into the threaded end of mounting plug 44. Lock nut 45 is used to secure the mounting stud at its desired position.

The hydraulic cylinder 50 is closed at its top by wall surface 52 and it has a piston 54 reciprocally mounted therein which forms a sealed chamber 56 between its top surface 52 and the interior of the cylinder. An O-ring 57 provides sealing contact between the piston and the interior walls of the cylinder. An entrance tube 60 and an exit tube 62 are connected to the sealed chamber 56. A pressure accumulator 64 is connected to entrance tube 60 and has control valve 65. The pressure accumulator 64 functions to maintain a source of hydraulic fluid under pressure. It would have a hydraulic chamber 66 on one side of piston 68 and a nitrogen chamber 70 on its other side. A gauge 72 could be attached to the end of the pressure accumulator to give a reading on the pressure within the nitrogen chamber.

The hydraulic fluid is supplied to the hydraulic chamber under pressure through tube 74. It has a check valve 75 to allow the fluid to only pass in one direction. The means for supplying the hydraulic fluid under pressure is a pump 77 such as that for the power steering of the automobile or an auxiliary gear pump could be utilized. The hydraulic fluid under pressure leaves pump 77 and passes through pressure regulator 79 on its way to the pressure accumulator 64. The exit tube 62 is connected to pump 77 and it has a control valve 80. The operation for varying the height of the fulcrum of the rocker lever 26 is accomplished by directing fluid under pressure into chamber 56 of the hydraulic cylinder 50. This fluid under pressure pushes against piston 54 causing it to travel downwardly until it contacts the top of pins 47. Continued travel of the piston 54 downwardly causes sleeve 46 to travel axially downwardly along the mounting stud 36 causing the fulcrum of the rocker lever to travel downwardly also. When the sleeve has traveled downwardly a pre-determined distance, the upward travel of the push rod 28 will cause valve 24 to be opened due to the rocker lever 26 rocking about its fulcrum point. In order to de-activate the operation of the valve, it is merely necessary to open control valve 80 which decreases the pressure within chamber 56 and causes sleeve 46 to move upwardly and along with it the fulcrum of the rocker lever.

When the operation of a valve has been de-activated, the modifications that are made to the bottom of the push rod 28 become operational. Shoulders 29 that have been formed on the bottom of the push rod 28 provide a stop against which collar 33 can rest. The underside of collar 33 receives the upper end of a light compression spring 31 whose lower end is captured in retainer 34. Spring retainer 34 is composed of a magnetized metal. An insulator 35 separates spring retainer 34 from the engine block. During normal operation of the valve train, cam 32 is rotated clockwise causing hydraulic lifter 30 to move from the position shown in FIG. 2 to the dotted line indicated by letter x. When the top of valve lifter 30 has traveled as high as level x, if the valve train has been de-activated, spring retainer 34 will magnetically attract valve lifter 30, thereby taking it out of contact with cam 32. The result is that push rod 28 will not reciprocate up and down while the valve train is deactivated and cam 32 will continue to rotate.

An alternative modification to the bottom of push rod 28 is illustrated in FIG. 3. In this embodiment, shoulders 29 have also been formed on the push rod for controlling the axial displacement of collar 33. The normal socket 89 in valve lifter 30 is initially removed therefrom and fixedly attached to the bottom of adaptor 85. The lower end of this unit is then reinserted into valve

lifter 30 and snap ring 88 positioned back in place. Adaptor 85 has a snap ring 82 that captures collar 83 that has been welded or otherwise fixedly secured on the lower end of push rod 28. A sleeve 87 provides a guide for adaptor 85 and also provides a mounting structure at its top to capture the bottom of light compression spring 31 whose top is captured by collar 33. When the valve train has been deactivated, the rotation by cam 32 will cause valve lifter 30 to have its top surface rise to the position of dotted line y. Since the fulcrum of the rocker lever has been raised upwardly, there will be no downwardly force exerted against push rod 28 and valve lifter 30 will remain at its high point y. This results in the immobility of push rod 28 while cam 32 still continues to rotate.

An alternative system for de-activating the exhaust and intake valve trains is illustrated in FIGS. 4 and 4a. In this system, a different push rod assembly would have to be substituted for a normal push rod. This push rod assembly is designated numeral 94 and it has an upper push rod 90 and a lower push rod 91. The top of upper push rod 90 is captured by the rocker lever 26. Upper push rod 90 also has a bore 92 extending its length and formed on the bottom of this member is a piston 93. Piston 93 is matingly received in the piston cylinder 95 that is formed at the top of lower push rod 91. Attached to the lower end of push rod 91 is a roller cam follower 96 that maintains contact with cam 32.

The system illustrated in these figures does not required the changing of the fulcrum of the rocker lever 26. Instead, the valve train is deactivated by upper push rod 90 and lower push rod 91, telescoping together a short distance. This action occurs when release valve 100 is opened causing the fluid beneath piston 93 to drain out of cylinder 95. As this occurs, and while cam 32 causes lower push rod 91 to travel upwardly, when it meets no resistance from fluid within the piston cylinder, there will be no force directed by upper push rod 90 against rocker lever 26 that is necessary to open the exhaust or intake valve to which the rocker lever is attached. When it is desired to activate the valve train, it is merely necessary to release fluid under pressure down through bore 92 past ball valve 102 that is held in position by spring 98. At this time, release valve 100 would have been closed and as the pressure builds within piston cylinder 95 upper push rod 90 will be driven upwardly its required distance to bring back into operation the valve train. O-rings 99 and 97 function to seal off the fluid that has been pumped down into piston cylinder 95. The fluid to be utilized in the control circuit could be the same as that illustrated in FIG. 2 with inlet tube 60 being connected to bore 92 and exit tube 62 being connected to release valve 100.

What is claimed is:

1. A cylinder de-activator system for an internal combustion engine comprising:

a block and an engine head,

a plurality of engine cylinders in said block, intake and exhaust valves for each engine cylinder spring loaded to their closed positions,

a cam operated valve train operating each said valve, said valve train comprising a rocker lever that has an aperture in its midsection that allows the rocker lever to be rockingly connected to a first mounting stud extending upwardly from said engine head, one end of said rocker lever presses against a coil spring that normally keeps said valve closed and the other end of said rocker lever receives the top of a push rod,

hydraulic means for varying the fulcrum position on said first mounting studs about which said rocker lever rocks, said hydraulic means comprising

a tubular sleeve having said first mounting stud extending upwardly within, the top of said tubular sleeve having a pressure force transfer surface,

a hydraulic cylinder having integral lateral walls that stretch continuously all the way from the bottom of said hydraulic cylinder to its top, the hydraulic cylinder has a top wall that closes that end of the cylinder, a piston is reciprocally mounted within said hydraulic cylinder and it forms a sealed chamber between its top surface and the interior of said hydraulic cylinder, the hydraulic cylinder has a bottom wall that closes that end of the cylinder, said bottom wall having a plurality of bores passing through it into which a plurality of force transfer pins are inserted, the lower end of said pins are supported on the force transfer surface of said tubular sleeve with the top ends of said pins forming pressure contact surfaces against which said piston is forced when hydraulic fluid under pressure enters said sealed chamber in the hydraulic cylinder to activate the valve for re-activating that cylinder of the engine.

a fluid pressure system having a source of hydraulic fluid under pressure connected to the sealed chamber in said hydraulic cylinder by at least one tube and control valves in the fluid pressure system to control the hydraulic force exerted against the top of the piston in said hydraulic cylinder.

2. A cylinder de-activator system for an internal combustion engine as recited in claim 1 wherein said hydraulic means for varying the fulcrum position of said rocker lever further comprises adjustable means for positioning said hydraulic cylinder a predetermined height above said sleeve.

3. A cylinder de-activator system for an internal combustion engine as recited in claim 2 wherein said means for positioning said hydraulic cylinder a predetermined height above said sleeve comprises a second mounting stud coupled at its lower end to the top of said first mounting stud with its top end coupled to a mounting plug that forms the bottom wall that closes the lower end of said hydraulic cylinder.

4. A cylinder de-activator system for an internal combustion engine as recited in claim 3 wherein the top of said second mounting stud is threaded into a threaded bore in said mounting plug whereby the height of the hydraulic cylinder above said sleeve can be adjusted.

5. A cylinder de-activator system for an internal combustion engine as recited in claim 1 further comprising means on the lower end of said push rod for de-activating its reciprocating travel by taking it out of cam follower contact with its cam when the fulcrum position on said first mounting stud is raised to its inoperative height.

6. A cylinder de-activator system for an internal combustion engine as recited in claim 5 wherein said means on the lower end of said push rod for de-activating its reciprocating travel comprises a valve lifter attached to the lower end of said push rod and magnetic means for locking the bottom of said valve lifter out of cam follower contact with its cam.

* * * * *

Attachment B
EPA-AA-TEB-81-7

EMISSIONS AND FUEL ECONOMY OF THE AUTOMOTIVE CYLINDER DEACTIVATOR SYSTEM (ACDS)

BY

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Background

The Environmental Protection Agency receives information about many systems which appear to offer potential for emission reduction or fuel economy improvement compared to conventional engines and vehicles. EPA's Emission Control Technology Division is interested in evaluating all such systems, because of the obvious benefits to the Nation from the identification of systems that can reduce emissions, improve fuel economy, or both. EPA invites developers of such systems to provide complete technical data on the system's principle of operation, together with available test data on the system. In those cases for which review by EPA technical staff suggests that the data available shows promise, confirmatory tests are run at the EPA Motor Vehicle Emission Laboratory at Ann Arbor, Michigan. The results of all such test projects are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The deactivation of one or more engine cylinders is a method that has been proposed as offering potential for vehicle fuel economy improvements. At low power output the throttle is nearly closed. This introduces a "throttling loss", which is the energy the engine must expend to draw the fuel-air mixture through the carburetor throttle opening. By operating an engine on a reduced number of cylinders and operating these at high power levels, the throttling losses are appreciably reduced. The operating cylinders are therefore run at a high brake-mean-effective pressure (BMEP) and therefore potentially more efficiently.

EPA received a request from Automotive Cylinder Deactivator System (ACDS) to perform a 511 evaluation of their cylinder deactivator. Section 511 of the Motor Vehicle Information and Cost Savings Act (15 USC 2011) requires EPA to evaluate fuel economy retrofit devices with regard to both emissions and fuel economy, and to publish the results in the Federal Register. Such an evaluation is based upon valid test data submitted by the manufacturer and, if required, EPA testing.

Data submitted by ACDS showed appreciable fuel economy benefits for some vehicles. Therefore EPA conducted a confirmatory test program on three different test vehicles as part of the evaluation. This report details the results of the confirmatory test program. However, this report is not the full detailed evaluation of the device. That evaluation is contained in the "Announcement of Fuel Economy Retrofit Device Evaluation for the Automotive Cylinder Deactivator System (ACDS)".

ACDS is developing both manual and semi-automatic means of cylinder deactivation. EPA agreed to test the vehicles only with one-half the cylinders deactivated throughout the total, device installed, test sequence. This would provide "worst case" emissions data, i.e. if emissions were negatively impacted by the concept, this should be the worst case. Utilization of the worst case would better permit an understanding of the relationship between benefits and penalties attributable to the concept.

EPA has also tested other cylinder deactivation systems. The Eaton system was tested in a demonstration Cadillac provided by Eaton. The

results of these tests are reported in TEB report 80-16 "Emissions and Fuel Economy Tests of a vehicle equipped with the Eaton Valve Selector". A prototype Cadillac was tested in a vehicle provided by the Cadillac Motor Division of General Motors. The results of these tests are reported in TEB report 80-14, "Emissions and Fuel Economy of a Cadillac Prototype with Modulated Displacement Engine". Six years ago EPA also tested a vehicle with 4 cylinders deactivated. The results of that test are given in TAEB report 75-11, "Evaluation of the MSU 4 Cylinder Conversion Technique for V-8 Engines."

The conclusions drawn from the EPA evaluation tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the evaluation test projects conducted by EPA. For promising systems it is necessary that more extensive test programs be carried out.

The conclusions from the EPA evaluation test can be considered to be quantitatively valid only for the specific test cars used; however, it is reasonable to extrapolate the results from the EPA test to other types of vehicles in a directional manner, i.e. to suggest that similar results are likely to be achieved on other types of vehicles.

Summary of Findings

Overall the use of the ACDS to operate an 8 cylinder engine on 4 cylinders caused CO and NOx emissions to increase substantially, moderate fuel economy increases, braking problems, and poor driveability.

HC emissions were relatively unaffected by ACDS 4 cylinder operation for both the FTP and HFET.

Use of ACDS to operate the engines on 4 cylinders caused 100% to 200% increases in FTP CO emissions to levels near or above the 1979 CO emission standard of 15.0 gm/mi. HFET CO emissions were increased to levels 20 to 100 times higher than baseline.

Use of ACDS to operate the engines on 4 cylinders caused FTP NOx emissions to rise to levels twice the 1979 NOx standard of 2.0 gm/mi. HFET NOx emissions were increased 9% to 55% by operation on less cylinders.

Because EPA tests showed that use of this device, on the vehicles tested caused emissions to exceed applicable standards, the installation of this device by a person in the business of servicing, repairing, selling, leasing, or trading motor vehicles, fleet operators, or new car dealers will be considered a violation of section 203(a)(3), the Federal prohibition against tampering with emission control systems. That is, there is currently no reasonable basis for believing that the installation or use of this device will not adversely affect emission performance. This determination does not preclude the use of the ACDS device on a different vehicle or vehicles than those tested by EPA if Federal Test Procedure tests performed on such vehicles clearly establish that emission performance on such vehicles is not adversely affected.

Many state laws prohibit the operation or registration for use on public highways of a motor vehicle on which the emission control device has been removed or rendered inoperative. EPA has concluded that this device will render inoperative an element of design of the emission control devices or systems of a motor vehicle on which it is installed. Therefore, the installation or use of this device by individuals may be prohibited under some state laws.

The operation of an 8 cylinder vehicle on 4 cylinders through the use of the ACDS hardware did improve vehicle fuel economy 5 to 16% for the FTP and 3 to 20% for the HFET, but with the associated emission increase described above.

The vehicles had poor driveablity when using the ACDS to operate on 4 cylinders.

The use of a higher octane fuel, indolene, had only a minor effect on vehicle emissions or fuel economy in the 4 cylinder mode. Driveability with 4 cylinders, was slightly worse with commercial unleaded.

Vehicle acceleration times were substantially increased when the 8 cylinder vehicles were operated with 4 cylinders using ACDS. Acceleration times were typically double the comparable times for 8 cylinder operation.

The operation of an 8 cylinder vehicle on 4 cylinders caused a serious loss of braking power assist under some driving conditions.

Operation of an 8 cylinder vehicle on 4 cylinders caused a reduction in the air conditioner airflow when accelerating.

No mechanical problems were encountered that were due to the ACDS hardware. However, no assessment of the durability of the ACDS system was made.

ACDS Description

The purpose of the ACDS is to deactivate one half of the engine cylinders. "This is accomplished by releasing the fulcrum point of the rocker arm, thereby allowing the intake and exhaust valves to stay closed on the deactivated cylinders. The kit also provides means for attaching the pushrod to the hydraulic lifter and furnishes a spring which holds the pushrod and lifter assembly up and away from the camshaft while deactivated".*

The cylinders to be deactivated are selected so that every other cylinder in the firing order is deactivated. This leads to the front and rear cylinders in one bank and the two center cylinders on the other bank being selected for deactivation.

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*ACDS product literature "Instruction Manual for Installation of Mechanical ACD System on small and big block Chevrolets", a copy of these instructions is given in the Appendix.

This selection of active and deactivated cylinders means that, on typical carburetor induction systems, the 4 active cylinders are fed the fuel-air mixture by one side of the carburetor and the 4 adjustable cylinders by the other side. Therefore when cylinders are deactivated, there is no air flow thru one side of the carburetor. Also, because the exhaust valves are closed on deactivated cylinders, there is no exhaust flow from deactivated cylinders.

The ACDS kit consists of two star clips, a washer, a spring, a pushrod, a wire clip and a rubber cup plug for each of the eight valves (4 intake and 4 exhaust) deactivated. The pushrod is usually identical to the stock pushrod. The wire clip is a slightly thicker and reshaped replacement for the valve lifter wire clip.

Installation of the ACDS requires removal of the intake manifold and valve covers. Ignition wires, hoses, fuel lines, and other engine hardware, as appropriate, must be removed to allow access to the valve lifters and rocker arm assemblies. The lifters are removed and the wire clip is removed. The lifters are re-installed and connected to the ACDS provided pushrod and spring assembly with the ACDS star clip and wire clip.

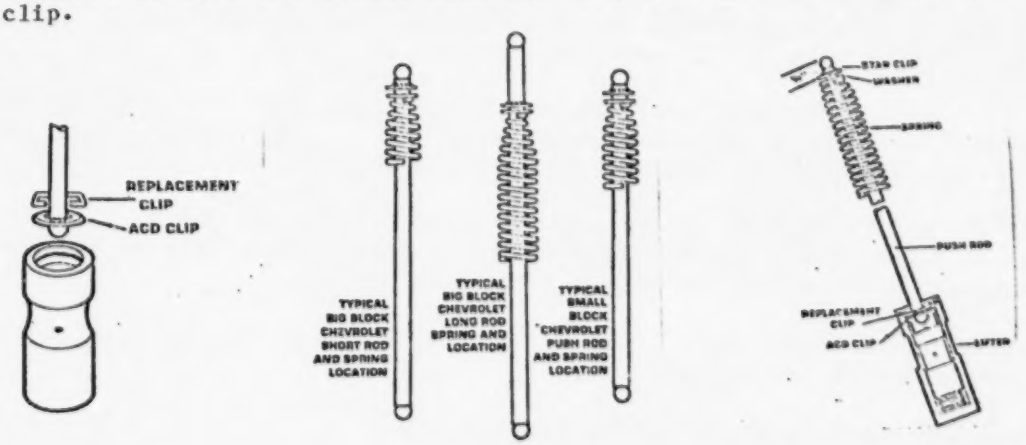

Figure 1
ACDS Hardware

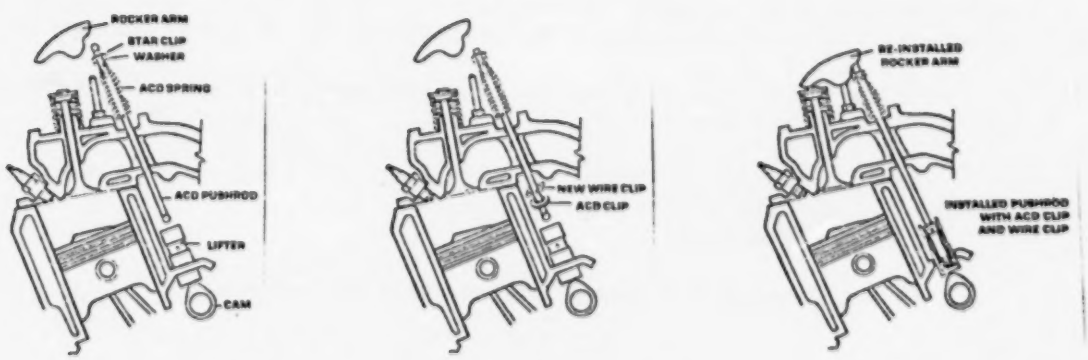

Figure 2
Typical Installation

During installation, 1-1/8 inch holes are drilled in the valve covers. These holes allow a socket wrench access to the rocker arm adjustment nut. This readily permits manual conversion of the engine back and forth between 4 cylinder and 8 cylinder modes. Rubber cup plugs are provided to cap these holes.

No vehicle engine adjustments are required unless specific problems are encountered.

Test Vehicle Description

Two of the test vehicles used in this study were selected on the basis of their being typical full sized, late model vehicles with large displacement V-8 engines. A third vehicle, a Capri, was selected to represent a current vehicle with a relatively larger power to weight ratio. These vehicles were obtained from automobile rental firms.

The three test vehicles used in this study were:

A 1979 Chevrolet Impala equipped with a 5.7 liter V-8 engine, automatic transmission and air conditioning. This vehicle used EGR and an oxidation catalyst for emission control.

A 1979 Mercury Capri equipped with a 5.0 liter V-8 engine, automatic transmission, and air conditioning. This vehicle used an air pump, EGR, and an oxidation catalyst for emission control.

A 1979 Mercury Cougar equipped with a 5.0 liter V-8 engine, automatic transmission and air conditioning. This vehicle used an air pump, EGR, and an oxidation catalyst for emission control.

A complete description of these vehicles is given in the test vehicle description in the Appendix.

Test Vehicle Inspection, Servicing, and Repair

Prior to baseline testing, each vehicle was given a specification check and inspection. The ignition timing, idle speed, and fast idle speed were checked for agreement with the manufacturer's specifications given on the Vehicle Emission Control Information label affixed to the engine compartment and adjusted if required. The vehicles were inspected for engine vacuum leaks, proper connection of vacuum hoses, functioning PCV valve, oil and water levels, and general condition of engine compartment.

The vehicles were also checked with an automotive diagnostic computer. The tests performed were:

(1) Cranking - checks battery, starter draw, cranking speed, dynamic distributor resistance, dwell, and relative cylinder compression.

(2) Alternator - checks alternator power output at 2500 rpm.

(3) Idle - checks rpm, dwell, HC and CO emissions, initial timing, PCV, and manifold vacuum.

(4) Low cruise - checks ignition coil output.

(5) Power balance - checks power output of individual cylinders.

(6) Snap acceleration - checks spark plugs under load.

(7) High cruise - checks ignition dwell, dwell variation, total timing advance.

The Impala and Capri passed the preceding tests. However, the Cougar had insufficient distributor vacuum and mechanical advance. The lack of vacuum advance was corrected by readjusting the vacuum advance control set screw. The lack of sufficient mechanical advance was corrected by grinding off part of the distributor plate to permit additional mechanical advance (it was later determined a part of the distributor plate was installed bac'wards). After these distributor changes, the Cougar passed the checkout tests.

The above mentioned Ford/Mercury distributor problem has been noted in other Ford vehicles being tested. Apparently the cause of the problem is that part of the distributor plate mechanism can be installed backwards. The unit then functions normally except that it cannot achieve the last few degrees of distributor mechanical advance.

The Impala and Cougar were serviced prior to testing. The air and oil filters were replaced and the engine oil was changed. The Capri had been serviced just prior to delivery and therefore required no servicing.

Test Procedures

Exhaust emission tests were conducted according to the 1977 Federal Test Procedure (FTP) described in the Federal Register of June 28, 1977 and the EPA Highway Fuel Economy Test (HFET) described in the Federal Register of September 10, 1976. The vehicles were not tested for evaporative emissions.

The vehicles were initially tested in the baseline (stock) configuration to determine their emissions and fuel economy performance. The vehicles were then modified by the installation of the ACDS hardware on 4 intake and 4 exhaust valves (ACDS hardware installed on 4 cylinders, no cylinders deactivated). They were then retested in 8 cylinder configuration to insure that emissions and fuel economy had not been changed by the installation process.

The vehicles were then placed in 4 cylinder operation. This was done by backing off the rocker arm fulcrum nut and allowing the ACDS hardware to pull the hydraulic lifter off the cam. The vehicles were tested for emissions and fuel economy with 4 cylinders.

In the 4 cylinder mode, each of the 4 active cylinders would have to work harder than in the 8 cylinder mode. These higher loads would tend to

increase the engine's octane requirement. Because the EPA test fuel (indolene) typically has a higher octane rating than commercial fuel, in the 4 cylinder mode the vehicles were tested with both indolene and commercial unleaded.

Additional tests were conducted as an evaluation tool. These consisted of steady state emission tests, acceleration tests, and road evaluations.

EPA supplied all three test vehicles. The Impala and Cougar were modified by ACDS personnel. The Capri was modified by EPA. Each initial conversion took several hours. Most of the installation time was required for removing and replacing engine components and gaskets. EPA did not modify the valve covers but removed them each time a change in the number of active cylinders was required.

Test Results

The objective of this test program was to evaluate the potential fuel economy benefits of an aftermarket cylinder deactivation system and to determine its effects on vehicle emissions. The test results are summarized in the tables and figures in the following paragraphs. More detailed tabulations of the data are given in the Appendix.

1. Federal Test Procedure (FTP) Results

Overall the operation of the vehicles on 4 cylinders caused CO and NOx emissions to increase dramatically. HC emissions were not changed substantially. In 4 cylinder mode, the vehicles failed to meet the 1979 emission standards of 1.5 gm/mi HC, 15 gm/mi CO, and 2.0 gm/mi NOx. Fuel economy increased 5 to 16%. Vehicle driveability was poor in some cases. The results are tabulated in Table I below. All results are the average of two tests unless noted otherwise.

TABLE I
AUTOMOTIVE CYLINDER DEACTIVATION SYSTEM - ACDS
AVERAGE FTP MASS EMISSIONS
grams per mile

TEST CONDITION	HC	CO	CO_2	NOx	MPG
CHEVROLET IMPALA					
8 cylinder baseline	.52	4.03	548	1.50	15.9
8 cylinder w/ACDS(3 tests)	.90	10.13	529	1.54	16.2
4 cylinder w/ACDS	.71	18.77	440	4.06	18.8
4 cylinder w/ACDS commercial unleaded	.79	22.36	440	4.04	18.5

MERCURY CAPRI					
8 cylinder baseline (3 tests)	.78	3.11	507	1.31	17.2
8 cylinder w/ACDS (3 tests)	.84	4.01	503	1.42	17.3
4 cylinder w/ACDS	.68	7.75	459	4.38	18.8
4 cylinder w/ACDS commercial unleaded	.89	16.41	460	4.13	18.1
MERCURY COUGAR					
8 cylinder baseline	.62	3.42	561	2.41	15.6
8 cylinder w/ACDS	.69	4.47	551	2.33	15.8
4 cylinder w/ACDS	.72	11.27	500	4.57	17.0
4 cylinder w/ACDS commercial unleaded	.69	12.44	504	4.86	16.9

FTP BASELINE (Stock) Tests

The purpose of the baseline tests was to insure before testing began, that all of these 1979 vehicles were representative and all of these 1979 vehicles met the 1979 emission standard. The Impala's and Capri's emission levels met the standard and were comparable to the certification tests. (See comparison to the certification vehicles and Table III).

The Cougar's NOx emissions were appreciably above the standard. This information was not available until after the vehicle had been modified. The Cougar's emission control system was functionally checked. A new EGR valve was installed, however the vehicle's emissions remained unchanged. Since several replacement vehicles were unacceptable, and this Cougar was modified, it was tested even though the baseline FTP NOx emissions were above the NOx standard.

In stock configuration, all vehicles had acceptable driveability.

FTP - 8 CYLINDER WITH ACDS MODIFICATION (NONFUNCTIONAL)

The purpose of this series of tests was to establish a reference and to insure that vehicle emissions and fuel economy had not been inadvertently changed because of the disassembly and reassembly operations required for installation of the ACDS hardware. Except for the Impala's CO emissions being doubled, none of the vehicles' emissions or fuel economy had shifted appreciably.

The Impala's CO emissions changed from 4.03 gm/mi to 10.13 gm/mi. The Cougar's CO emissions tended to increase slightly. The exact cause for these changes was not determined. Since the vehicle's emissions were still acceptable (met the standard and similar to the certification levels),

testing was continued without additional adjustment of these vehicles. The Capri's and Cougar's emissions and fuel economy were essentially unchanged.

With 8 cylinders operating and ACDS installed, but nonfunctional, driveability remained acceptable.

FTP - 4 CYLINDER WITH ACDS MODIFICATION - INDOLENE FUEL

The vehicles were converted to 4 cylinder operation by deactivating 4 cylinders. This was done by releasing the rocker arm fulcrum nut thus permitting the ACDS hardware to pull the intake and exhaust lifters off the camshaft. As noted before, this caused CO and NOx emission penalties, fuel economy benefits, and driveability problems.

The Impala's HC emissions were decreased 21%. CO emissions doubled to 18.77 gm/mi, a level 25% above the CO emission standard. NOx emissions increased by 160% to 4.06 gm/mi, double the allowable standard. Fuel economy increased 16%. Driveability was acceptable.

The Capri's HC emissions were decreased 19%. CO emissions doubled to 7.75 gm/mi. NOx emissions tripled to 4.38 gm/mi, over double the allowable standard. Fuel economy increased 9%. Driveability was fair. There were numerous transmission shifts. The vehicle had insufficient power to follow the driving schedule during hard acceleration.

The Cougar's HC emissions were not significantly affected. CO emission tripled to 11.27 gm/mi. NOx doubled to 4.57 gm/mi, over double the allowable standard. Fuel economy increased 8%. Driveability was marginal. There were numerous transmission downshifts and upshifts. The vehicle had insufficient power to follow the driving schedule during hard accelerations.

FTP - 4 CYLINDER WITH ACDS MODIFICATION - COMMERCIAL UNLEADED

As previously noted, EPA's indolene unleaded test fuel typically has a higher octane rating than commercial unleaded gasoline. Since the test vehicles would probably be more octane sensitive in 4 cylinder mode than 8 cylinder mode, the 4 cylinder tests were repeated using a commercial unleaded gasoline. The octane ratings of these fuels were:

	Indolene unleaded	Commercial unleaded
Motor Octane Number	88.65	82.57
Research Octane Number	97.45	91.55
$\frac{M+R}{2}$ (combined)	93.05	87.06

The combined number is the value typically posted on the service station pumps.

When tested with commercial unleaded gasoline, all three vehicle's emissions and fuel economy followed trends noted previously for indolene. However, there was additional driveability deterioration, especially detonation. Compared to the 8 cylinder configuration, in 4 cylinder operation, the Impala's HC emissions decreased 13%, but CO emissions further increased to 22.36 gm/mi. NOx emissions were again increased 160% to 4.04 gm/mi. Fuel economy again increased 14%. Driveability was poor. There was considerable hesitation and detonation on accelerations.

Compared to the 8 cylinder configuration, in 4 cylinder operation the Capri's CO emissions, NOx emissions, and fuel economy followed the same trend noted previously for indolene. HC emissions increased 6%, CO emissions increased by a factor of 5 to 16.41 gm/mi, a level that exceeds the CO emission standard. NOx emissions tripled to 4.13 gm/mi, over double the allowable standard. Fuel economy increased 5%. Driveability was fair. There were numerous transmission shifts. The vehicle lacked power for hard accelerations. There was minor detonation on most accelerations.

Compared to the 8 cylinder configuration, in 4 cylinder operations, the Cougar's emissions and fuel economy followed the same trends noted previously for indolene. HC emissions were unchanged. CO emissions tripled to 12.44 gm/mi. NOx doubled to 4.86 gm/mi. Fuel economy increased 7%. Driveability was again marginal. There were numerous transmission downshifts and upshifts. The vehicle had insufficient power to follow the driving schedule during most accelerations. The engine had a tendency to "diesel" when shut-off.

2. Highway Fuel Economy Test (HFET) Results

Overall the operation of the vehicles on 4 cylinders caused CO and NOx emissions to increase substantially. HC emissions were relatively unchanged. Fuel economy increased 3 to 20%. Vehicle driveability was adversely affected in some cases. These results are Tabulated in Table II below. All results are for two tests unless otherwise noted.

TABLE II

Automotive Cylinder Deactivation System - ACDS
Average HFET Mass Emission
grams per mile

TEST CONDITION CHEVROLET IMPALA	HC	CO	CO_2	NOx	MPG
8 cylinder baseline	.12	.14	383	1.46	23.1
8 cylinder w/ACDS (3 tests)	.10	.16	375	1.37	23.7
4 cylinder w/ACDS	.20	5.48	303	1.78	28.4
4 cylinder w/ACDS commercial unleaded	.40	16.12	289	1.92	28.1

MERCURY CAPRI

8 cylinder baseline (3 tests)	.24	.07	374	1.31	23.7
8 cylinder w/ACDS (3 tests)	.22	.11	373	1.37	23.8
4 cylinder w/ACDS	.13	1.47	351	2.12	25.1
4 cylinder w/ACDS commercial unleaded	.13	4.41	353	2.08	24.6

MERCURY COUGAR

8 cylinder baseline	.17	.31	403	2.54	22.9
8 cylinder w/ACDS	.18	.56	400	2.42	22.1
4 cylinder w/ACDS	.16	4.30	363	2.64	24.0
4 cylinder w/ACDS commercial unleaded	.12	3.33	363	2.67	24.1

HFET BASELINE (STOCK) TESTS

The purpose of these tests was to insure the vehicles' HFET fuel economy were representative. The three vehicles' HFET fuel economy were reasonably comparable to the certification tests. (See comparison to the certification fuel economy vehicles and Table III). The vehicles' emissions and fuel economy were acceptable. Driveability was acceptable.

HFET - 8 CYLINDER WITH ACDS MODIFICATION

The purpose of this group of tests was to establish a reference and to insure the vehicles' emissions and fuel economy had not inadvertently changed during the inital ACDS installation. The emissions and fuel economy of all three vehicles had not significantly changed during modification. Driveability remained acceptable.

HFET - 4 CYLINDER WITH ACDS MODIFICATION - INDOLENE FUEL

The Impala's emissions and fuel economy increased. HC emission doubled to .20 gm/mi. CO increased substantially to 5.48 gm/mi. NOx increased by 30% to 1.78 gm/mi. Fuel economy increased 20% to 28.4 mpg. Driveability was acceptable.

The Capri showed similar emissions and fuel economy trends. HC decreased by one third. CO increased substantially to 1.47 gm/mi. NOx increased by 50% to 2.12 gm/mi. Fuel economy increased 5% to 25.1 mpg. However, the Capri's driveability was fair. There were numerous tranmission shifts and insufficient power to accelerate.

The Cougar also followed these emissions and fuel economy trends. HC remained unchanged. CO increased substantially to 4.30 gm/mi. NOx tended to increase slightly. Fuel economy showed a 9% increase. Drive-

ability was marginal. There was insufficient power for acceleration and the transmission shifted more frequently than normal.

HFET - 4 CYLINDER WITH ACDS MODIFICATION - COMMERCIAL UNLEADED GASOLINE

All three vehicles followed the trends previously noted in 4 cylinder operation. However, as with the FTP, there was again an additional loss in driveability when a commercially available fuel was used.

Compared to the 8 cylinder configuration, the Impala's HC emissions quadrupled. CO emissions rose to 16.12 gm/mi, three times greater than the tests using indolene and 100 times greater than the baseline. NOx emissions increased 40% to 1.92 gm/mi. Fuel economy again increased 19%. Driveability was very marginal. There was hesitation and considerable detonation on acceleration.

Compared to the 8 cylinder configuration the Capri's emissions followed the same trends noted previously for Indolene. HC was decreased one third. CO increased substantially to 4.41 gm/mi. Fuel economy again increased 3% to 24.6 mpg. Driveability was fair. There were numerous transmission shifts and insufficient power to accelerate.

Compared to the 8 cylinder configuration, the Cougar's emissions and fuel economy followed the trends noted for indolene. Namely HC was decreased by one third and there was a substantial increase in CO emissions to 3.33 gm/mi. NOx tended to increase slightly and fuel economy increased 9%. Driveability was again conditionally acceptable.

3. COMPARISON OF TEST VEHICLES TO CERTIFICATION VEHICLES

For comparison, the emission and fuel economy results for comparable 1979 vehicles are given in the tables below. These vehicles had the same displacement engine, same engine emission family, and same inertia test weight as the comparable test vehicle.

TABLE III
1979 CERTIFICATION VEHICLES
Typical FTP Mass Emissions
grams per mile

Vehicle	HC	CO	NOx	Fuel Economy FTP MPG	HFET MPG
1979 Chevrolet Impala	.57	8.1	1.6	15.0	19.0
1979 Mercury Capri	.63	6.9	1.3	16.7	23.0
1979 Mercury Cougar	.49	6.9	1.7	14.7	20.2

These emission values include the appropriate deterioration factor for each emission family. The most notable deviations of the three test vehicles from the above certification results were:

1) The Capri's and Cougar's FTP CO emissions (stock) were about half the comparable certification value.

2) The Mercury Cougar's FTP NOx emissions (stock) were above the standard and approximately 1.0 gm/mile above its certification levels.

3) All three test vehicles FTP fuel economy (stock) were approximately one mpg higher than the comparable certification vehicle.

4) All three test vehicles HFET fuel economy (stock) were one to two mpg higher than the comparable certification vehicle.

Therefore, except for the Cougar's previously noted high NOx levels, the vehicles were accepted as being representative of their make and model year.

4. COMBINED FUEL ECONOMY

A vehicles' combined Fuel Economy is calculated by using its weighted FTP and HFET fuel economy. The weighting is 55% FTP and 45% HFET. These values are harmonically averaged using the formula:

$$\text{combined fuel economy} = 1/\left(\frac{.55}{\text{FTP}} + \frac{.45}{\text{HFET}}\right) \text{ mpg}$$

The results for these test vehicles are:

Combined Fuel Economy
(indolene test fuel)

	8 cylinder	4 cylinder w/ACDS	percent change
Chevrolet Impala	18.9	22.2	17.4%
Mercury Capri	19.7	21.2	7.8%
Mercury Cougar	18.1	19.6	7.9%

5. STEADY STATE TESTS

The largest net increases and largest percentage increases in fuel economy occurred in the steady state test on all vehicles. HC and CO emissions were relatively unaffected by operation of the vehicles with only 4 active cylinders. The Impala's NOx emissions were also unaffected. However both the Capri and Cougar had large increases in NOx emissions. Best fuel economy for all vehicles was achieved at speeds between 25 and 35 mph. The steady state test results are tabulated in Tables XII, thru XIV in the Appendix. The fuel economy results are also plotted in Figure 3.

The vehicles were also tested for steady state fuel economy on the road tests. The results of these tests are given in Tables XI, XII, and XIII in the Appendix. In general, there was good agreement between the steady state road test and chassis dynamometer test fuel economies. The most noticeable difference was for the Impala at 25 mph. Apparently the vehicle's transmission had not shifted into high gear when tested on the dynamometer.

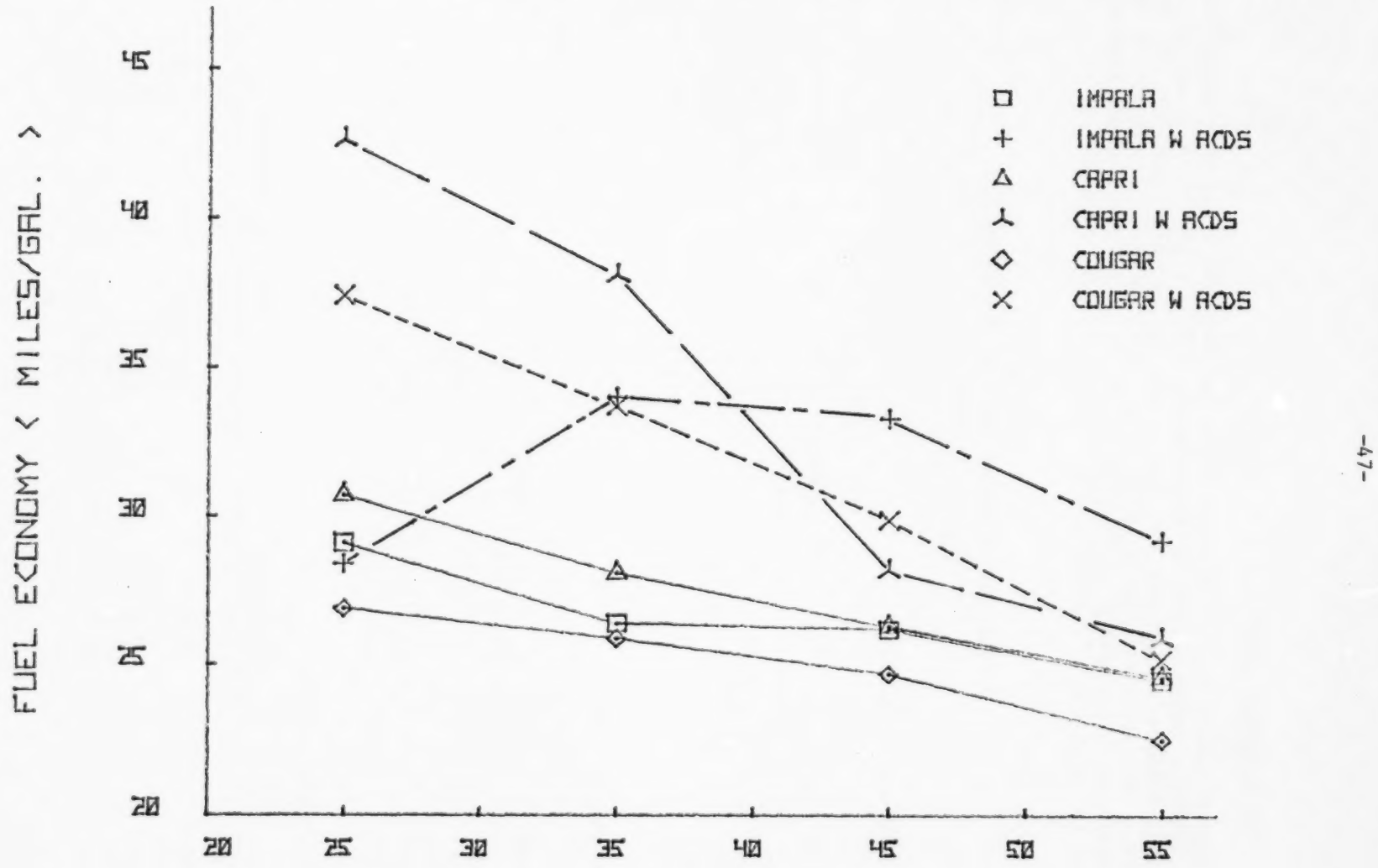

Figure 3 8 cylinder and 4 cylinder (ACDS) fuel economy - dynamometer

6. ACCELERATION TESTS

At the conclusion of the emission tests, acceleration tests were performed on the vehicles using a chassis dynamometer. To minimize tire slippage, the chassis dynamometer's front and rear rolls were coupled together for these tests. The vehicles' speed versus time acceleration characteristics were recorded on a calibrated strip chart recorder. The results are summarized below in Table IVa. Complete results are given in the Appendix.

Table IVa
Average Acceleration Times on the Dynamometer
seconds

1979 Chevrolet Impala

Speed	8 cylinder commercial unleaded	ACDS (4 cylinder) indolene unleaded
0-20	3.1	5.5
0-30	4.5	8.8
0-40	6.1	12.3
0-50	8.3	17.1
0-60	11.2	23.7

1979 Mercury Capri

Speed	8 cylinder commercial unleaded	ACDS (4 cylinder) indolene unleaded
0-20	3.8	6.3
0-30	5.6	9.8
0-40	7.8	14.4
0-50	10.3	21.5
0-60	14.1	29.4

1979 Mercury Cougar

Speed	8 cylinder indolene unleaded	ACDS (4 cylinder) indolene unleaded	ACDS (4 cylinder) commercial unleaded
0-20	3.0	7.0	6.6
0-30	5.0	11.1	10.8
0-40	7.3	16.1	15.6
0-50	10.0	23.0	22.6
0-60	13.9	--	33.4

During the steady state fuel economy road testing, the vehicles' acceleration capability was also tested. The vehicles' speed versus time characteristics were taken by the use of a stopwatch and the vehicles' speedometer. This was considerably less precise than the preceding dynamometer tests. The test results are summarized in Table IVb below. Complete results are given in the Appendix.

Table IVb
AVERAGE ACCELERATION TIMES ON THE ROAD
seconds

1979 Chevrolet Impala — Not Tested

1979 Mercury Capri

Speed	8 cylinder	ACDS (4 cylinder) indolene unleaded
0-20	Not	6.2
0-30	Tested	9.9
0-40		13.8
0-50		20.7

1979 Mercury Cougar

Speed	8 cylinder	ACDS (4 cylinder)
0-20	--	7.2
0-30	4.8	11.4
0-40	7.2	16.5
0-50	9.5	23.7

Acceleration times were substantially increased by operation of the engine on only 4 cylinders. Acceleration times were only slightly affected by the type of fuel used. Acceleration times for the dynamometer and road tests were similar.

7. SAFETY

During the road tests, braking problems were encountered with the Impala. At times there was no braking power assist when the vehicle was operated with 4 cylinders deactivated. The source of this problem was the low manifold vacuum available during most of the operation on 4 cylinders. Therefore a repeated series of accelerations and braking could reduce the power brake's vacuum reservoir vacuum to levels that are unable to provide power brake assist. This could readily occur in heavy slow speed traffic or when highway cruising is followed immediately by a series of brake applications. This problem was further aggravated when the air conditioning was on, since the air conditioner caused the loss of an additional 2-4 inches of vacuum.

A braking problem was not encountered with the other two vehicles. However, they were not driven in similar heavy traffic conditions and it is, therefore, not known if they too are susceptible to this braking problem.

8. OTHER

When accelerating with only 4 cylinders operating, the Impala's engine vacuum provided insufficient vacuum to the air conditioner control system. This lack of vacuum caused the air conditioner air valves to partially shut and thus greatly reduced the cool air flow when accelerating. The two Mercury's were not checked to see if a similar problem occurred.

When converted to 4 cylinders, the vehicle's idle speed (neutral) typically increased several hundred rpm. However, as soon as the vehicle was placed in gear, idle speed dropped below normal idle (drive) speed and the vehicles had a tendency to stall, especially if the air conditioner was on. (The idle speed was not adjusted since readjustment of idle speed was not given in the ACDS instructions).

When cranking the vehicles (4 cylinder operation) the starter would momentarily stop due to the loads imposed by the 4 deactivated cylinders. This problem was more prevalent for warm engines. A limited check indicated peak starting currents were twice as high as normal. This indicates that there may be starting problems for vehicles with weak batteries or starting systems.

Although the vehicles accelerated much slower on 4 cylinders, once a cruise speed was achieved, the vehicles decelerated slowly when the driver's foot was removed from the accelerator. Therefore, there was negligible engine braking.

Appendix

TEST VEHICLE DESCRIPTION

Chassis model year/make-1979 Chevrolet Impala
Vehicle I.D. 1L47L9S115799

Engine

type	Otto Spark, V-8, OHV
bore x stroke	4.00 x 3.48 in/101.6 x 88.4 mm
displacement	350 CID/5.7 liter
compression ratio	8.3:1
maximum power @ rpm	170 hp/ 126 kW
fuel metering	4 venturi carburetor
fuel requirement	unleaded, tested with indolene HO unleaded, and a commercial unleaded

Drive Train

transmission type	3 speed automatic
final drive ratio	2.41

Chassis

type	2 door sedan
tire weight	FR 78 x 15
curb weight	3840 lb/1742 kg
inertia weight	4000 lb.
passenger capacity	6

Emission Control System

basic type	EGR Oxidation Catalyst

Vehicle odometer mileage	17050 miles at start of test program.

TEST VEHICLE DESCRIPTION

Chassis model year/make-1979 Mercury Capri

Vehicle I.D. 9F16F638851

Engine

type	Otto spark, V-8, OHV
bore x stroke	4.00 x 3.00 in./101.6 x 76.2 mm
displacement	302 CID/5.0 liter
compression ratio	8.4:1
maximum power @ rpm	135/101 kW.
fuel metering	2 venturi carburetor
fuel requirement	unleaded, tested with indolene HO unleaded and a commercial unleaded

Drive Train

transmission type	3 speed automatic
final drive ratio	2.47

Chassis

type	2 door sedan
tire size	CR 78 x 14
inertia weight	3500 lbs.
passenger capacity	4

Emission Control System

basic type	Air Pump EGR Oxidation catalyst

Vehicle odometer mileage..... 13,800 miles at start of program.

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1979 Mercury Cougar
Vehicle I.D. 9H93F692442

Engine

type	Otto spark, V-8 OHV
bore x stroke	4.00 x 3.00 in/101.6 x 76.2 mm
displacement	302 CID/5.0 liter
compression ratio	8.4:1
maximum power @ rpm	135 hp/101 kW
fuel metering	2 venturi carburetor
fuel requirement	unleaded, tested with indolene HO unleaded and a commercial unleaded

Drive Train

tranmission type	3 speed automatic
final drive ratio	2.75

Chassis

type	2 door sedan
tire size	GR 78x 15
inertia weight	4500 lb
passenger capacity	6

Emission Control System

basic type	Air Pump EGR Oxidation catalyst

Vehicle odometer mileage..... 16,850 miles at start of test program

TABLE V

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
ON 1979 CHEVROLET IMPALA
FTP Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 Cylinder stock					
80-1805		.52	3.88	555	1.47	15.8
80-1807		.52	4.18	541	1.53	16.1
	8 cylinder w/ACDS					
80-1938		.84	9.08	530	1.46	16.2
80-1975		.83	9.54	529	1.49	16.2
80-2455		1.03	11.77	527	1.67	16.2
	4 Cylinder w/ACDS					
80-1829		.66	15.91	436	4.20	19.2
80-1833		.76	21.63	443	3.91	18.5
	4 Cylinder w/ACDS	Commercial unleaded				
80-1835		.85	23.88	439	4.08	18.5
80-1912		.73	20.84	441	3.99	18.6

TABLE VI

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS)TEST
on MERCURY CAPRI
FTP Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 cylinder stock					
80-2016		.77	3.33	508	1.27	17.2
80-2020		.78	2.67	505	1.31	17.3
80-2151		.78	3.34	509	1.34	17.2
	8 cylinder w/ACDS					
80-2133		.79	3.45	501	1.44	17.4
80-2135		.80	3.62	502	1.51	17.4
80-3089		.92	4.97	507	1.32	17.1
	4 cylinder w/ACDS					
80-2421		.67	7.45	459	4.38	18.8
80-2423		.69	8.04	458	4.39	18.8
	4 cylinder w/ACDS Commercial unleaded					
80-2417		1.00	20.79	467	4.16	17.6
80-2419		.77	12.02	453	4.10	18.7

TABLE VII

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on MERCURY COUGAR
FTP Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NOx	MPG
	8 Cylinder stock					
80-1724		.61	2.95	562	2.51	15.6
80-1726		.62	3.88	560	2.31	15.6
	8 Cylinder w/ACDS					
80-1743		.62	3.60	548	2.47	16.0
80-2457		.75	5.33	554	2.18	15.7
	4 Cylinder w/ACDS					
80-1744		.73	12.33	499	4.73	17.0
80-1748		.71	10.20	501	4.41	17.1
	4 Cylinder w/ACDS Commercial unleaded					
80-2219		.73	12.88	500	4.89	17.0
80-2221		.64	12.00	507	4.82	16.8

TABLE VIII

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 CHEVROLET IMPALA
HFET Emissions
grams per mile

Test No.	HC	CO	CO_2	NO_x	MPG
8 Cylinder stock					
80-1806	.11	.18	387	1.48	22.9
80-1808	.12	.10	379	1.43	23.4
8 Cylinder after ACDS modification					
80-1937	.10	.01	360	1.23	24.6
80-1976	.10	.02	371	1.42	23.9
80-2456	.11	.44	394	1.46	22.5
4 Cylinder w/ACDS					
80-1830	.19	4.88	302	1.84	28.6
80-1834	.21	6.08	304	1.72	28.2
4 Cylinder w/ACDS Commercial unleaded					
80-1836	.47	19.32	283	1.86	28.2
80-1913	.33	12.92	294	1.98	28.1

TABLE IX

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 MERCURY CAPRI
HFET Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 Cylinder stock					
80-2017		.24	.06	376	1.27	23.5
80-2104		.25	.05	375	1.32	23.6
80-2152		.24	.09	370	1.34	23.9
	8 Cylinder w/ACDS					
80-2134		.25	.03	371	1.35	23.9
80-2136		.15	.00	366	1.42	24.2
80-3090		.27	.29	381	1.34	23.3
	4 Cylinder w/ACDS					
80-2422		.13	1.55	355	2.17	24.8
80-2424		.12	1.38	346	2.07	25.4
	4 Cylinder w/ACDS	Commercial unleaded				
80-2418		.13	5.96	355	2.06	24.3
80-2420		.13	2.86	350	2.09	25.0

TABLE X

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 MERCURY COUGAR
HFET Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 Cylinder Stock					
80-1725		.17	.24	406	2.57	21.8
80-1727		.16	.37	400	2.51	22.1
	8 Cylinder w/ACDS					
80-1918		.17	.17	396	2.47	22.3
80-2458		.18	.95	403	2.37	21.9
	4 Cylinder w/ACDS					
80-1745		.16	3.65	358	2.63	24.4
80-1749		.15	4.94	367	2.64	23.6
	4 Cylinder w/ACDS	Commercial unleaded				
80-2220		.12	2.52	361	2.81	24.3
80-2222		.12	4.13	364	2.52	23.9

TABLE XI

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 CHEVROLET IMPALA
Steady State Emissions
grams per mile *

Test No.	SPEED	HC	CO	CO_2	NO_x	MPG	Road Test Avg. MPG
	8 Cylinder Stock						
80-1809	0 mph*	2.90	.00	4957	1.47	.53	
80-1809	25 mph	.22	.00	302	.17	29.3	
80-1842	35 mph	.46	.00	360	.34	24.5	
80-1842	45 mph	.23	.00	346	.54	25.6	
80-1842	55 mph	.08	.00	372	1.30	23.8	
	8 Cylinder after ACDS Modification						
80-1827	0 mph	2.68	.00	4506	1.71	.50	
80-1827	25 mph	.23	.00	304	.19	29.1	
80-1828	35 mph	.31	.00	335	.34	26.4	
80-1828	45 mph	.16	.00	338	.65	26.2	
80-1828	55 mph	.07	.00	362	1.79	24.5	
	4 Cylinder w/ACDS						
80-1831	0 mph	.84	.15	4605	4.75	.53	@79° F
80-1831	25 mph	.09	.01	312	.17	28.4	39.9
80-1832	35 mph	.13	.00	261	.23	34.0	36.4
80-1832	45 mph	.07	.00	266	.57	33.3	34.6
80-1832	55 mph	.04	.00	304	1.21	29.2	29.2

*0 MPH (idle) speeds emission values are given in grams per hour and gallons per hour.

TABLE XII

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 MERCURY CAPRI
Steady State Emissions
grams per mile *

Test No.	SPEED	HC	CO	CO_2	NO_x	MPG	Road Test Avg. MPG
	8 Cylinder Stock						
80-2019	0 mph*	4.39	.00	4866	3.85	.56	
80-2019	25 mph	.29	.00	695	1.50	12.7	
80-2018	35 mph	.55	.14	323	.90	27.3	
80-2018	45 mph	.38	.00	343	.76	25.8	
80-2018	55 mph	.18	01	368	1.25	24.1	
	8 Cylinder after ACDS Modification						
80-2138	0 mph*	4.35	.00	4779	4.80	.53	@ 70° F
80-2138	25 mph	.16	.09	289	.71	30.7	29.9
80-2137	35 mph	.52	.00	314	.93	28.1	28.2
80-2137	45 mph	.39	.01	336	.81	26.3	26.4
80-2137	55 mph	.20	.01	360	1.39	24.6	24.9
	4 Cylinder w/ACDS						
80-2650	0 mph	3.85	.46	4882	16.99	.56	@ 83° F
80-2426	0 mph	5.49	.20	4086	44.06	.45	
80-2650	25 mph	.32	.07	204	1.83	43.2	40.1
80-2426	25 mph	.40	.18	210	2.09	42.0	
80-2650	35 mph	.21	.00	230	4.36	38.4	38.2
80-2425	35 mph	.21	.01	234	4.45	37.8	
80-2651	45 mph	.11	.01	316	.62	28.0	32.1
80-2425	45 mph	.10	.01	312	.66	28.4	
80-2651	55 mph	.07	.01	339	1.40	26.2	26.5
80-2425	55 mph	.07	.02	346	1.47	25.6	

* 0 mph (idle) speed emission values are given in grams per hour and gallons per hour.

TABLE XIII

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 MERCURY COUGAR
Steady State Emissions
grams per mile*

Test No.	SPEED	HC	CO	CO_2	NO_x	MPG	Road Test Avg. MPG
	8 Cylinder stock						
80-1838	0*	2.44	.00	4053	1.83	.46	@ 70° F
80-1838	25 mph	.12	.02	329	1.16	26.9	27.7
80-1837	35 mph	.40	.00	341	1.46	25.9	26.2
80-1837	45 mph	.18	.00	359	1.58	24.7	25.5
80-1837	55 mph	.13	.01	394	2.51	22.5	22.5
	4 Cylinder w/ACDS						
80-1746	0 mph*	2.36	1.08	4596	14.45	.53	@ 65° F
80-1746	25 mph	.14	.01	237	3.20	37.4	38.9
80-1747	35 mph	.19	.00	262	4.98	33.7	33.1
80-1747	45 mph	.15	.00	296	2.41	29.9	31.5
80-1747	55 mph	.11	.02	351	2.07	25.2	27.4
	4 Cylinder w/ACDS Commercial unleaded						
80-2269	0 mph*	3.46	.31	4131	7.98	.48	
80-2269	25 mph	.12	.00	237	2.94	37.3	
80-2273	35 mph	.15	.00	264	4.12	33.6	
80-2273	45 mph	.12	.00	297	2.15	29.8	
80-2273	55 mph	.08	.04	359	1.85	24.7	

* 0 mph (idle) speed emission values are given in grams per hour and gallons per hour.

TABLE XIV
Dynamometer Acceleration Tests on 1979 Chevrolet Impala
seconds

	8 Cylinder Indolene unleaded			ACDS 4 Cylinder Indolene unleaded gasoline	
SPEEDS	Run 1	Run 2	Run 3	Run 1	Run 2
0 - 5 MPH	1.0	1.5	1.2	1.2	1.0
0 - 10 MPH	1.6	2.2	1.8	2.6	2.1
0 - 15 MPH	2.2	2.8	2.4	4.0	3.5
0 - 20 MPH	2.8	3.3	3.1	5.7	5.2
0 - 25 MPH	3.4	4.0	3.7	7.4	6.9
0 - 30 MPH	4.2	4.8	4.5	9.0	8.5
0 - 35 MPH	5.0	5.6	5.2	10.8	10.3
0 - 40 MPH	5.8	6.3	6.1	12.5	12.0
0 - 45 MPH	6.8	7.3	7.0	14.4	13.9
0 - 50 MPH	8.0	8.6	8.2	17.2	16.9
0 - 55 MPH	9.5	10.0	9.6	20.3	19.9
0 - 60 MPH	11.0	11.6	11.0	24.0	23.3

TABLE XVa
Dynamometer Acceleration Tests on 1979 Mercury Capri
seconds

	8 Cylinder Indolene Unleaded Gasoline		ACDS 4 Cylinder Indolene Unleaded			
SPEEDS	Run 1	Run 2	Run 1	Run 2	Run 3	Run 4
0 - 5 MPH	1.3	1.4	2.0	1.9	1.5	1.3
0 - 10 MPH	2.1	2.1	3.2	3.2	2.8	2.6
0 - 15 MPH	3.0	2.8	4.6	5.1	4.4	4.1
0 - 20 MPH	3.9	3.7	6.4	6.8	6.2	5.9
0 - 25 MPH	4.7	4.6	8.1	8.4	8.0	7.6
0 - 30 MPH	5.7	5.5	9.8	10.2	9.8	9.4
0 - 35 MPH	6.8	6.4	11.9	12.3	11.9	11.5
0 - 40 MPH	8.0	7.5	14.3	14.8	14.3	14.0
0 - 45 MPH	9.3	8.5	17.5	18.0	17.5	17.2
0 - 50 MPH	10.8	9.8	21.7	22.6	21.0	20.7
0 - 55 MPH	12.9	11.4	25.4	26.0	24.9	24.5
0 - 60 MPH	15.2	13.0	-	-	29.8	29.0

TABLE XVb
Road Acceleration Tests on 1979 Mercury Capri
seconds

SPEEDS	8 Cylinder	ACDS 4 Cylinder Run 1	Run 2	Run 3	Run 4	Run 5
0 - 20 MPH		7.5	5.8	6.0	5.8	5.7
0 - 30 MPH	Not	11.5	9.2	9.5	9.5	9.8
0 - 40 MPH	Tested	15.5	13.4	13.5	13.4	13.3
0 - 50 MPH		23.5	19.7	20.0	20.2	20.0

TABLE XVIa
Dynamometer Acceleration Tests on 1979 Mercury Cougar
seconds

SPEEDS	8 Cylinder Indolene unleaded Gasoline Run 1	Run 2	ACDS 4 Cylinder Commercial Unleaded Run 1	Run 2	ACDS 4 Cylinder Indolene Gasoline Run 1	Run 2
0 - 5 MPH	.8	.8	1.8	1.5	1.5	1.5
0 - 10 MPH	1.5	1.4	3.3	3.2	2.9	2.9
0 - 15 MPH	2.2	2.1	5.0	4.9	4.6	4.6
0 - 20 MPH	3.0	3.0	7.0	6.9	6.6	6.6
0 - 25 MPH	4.0	3.9	8.9	9.0	8.6	8.6
0 - 30 MPH	5.0	4.9	11.0	11.2	10.7	10.8
0 - 35 MPH	6.1	6.0	13.3	13.4	13.0	13.1
0 - 40 MPH	7.4	7.2	16.0	16.2	15.6	15.6
0 - 45 MPH	8.6	8.5	19.5	19.5	19.0	19.1
0 - 50 MPH	10.0	9.9	22.9	23.1	22.5	22.6
0 - 55 MPH	11.9	11.8	28.0	28.1	27.4	27.4
0 - 60 MPH	13.9	13.8	-	-	33.4	33.3

TABLE XVIb
Road Acceleration Tests on 1979 Mercury Cougar
seconds

SPEEDS	8 Cylinder Indolene unleaded Gasoline Run 1	Run 2	Run 3	Run 4	ACDS 4 Cylinder Indolene Gasoline Run 1	Run 2	Run 3
0 - 20 MPH	- -	- -	- -	- -	7.5	7.2	7.0
0 - 30 MPH	4.5	5.5	4.6	4.5	11.8	11.2	11.1
0 - 40 MPH	6.8	8.2	7.0	6.7	16.7	16.2	16.7
0 - 50 MPH	9.1	10.0	9.5	9.2	23.5	24.5	23.2

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INSTALLATION INSTRUCTIONS ON ANY GM V8 ENGINE

HOW IT WORKS

The purpose of this kit is to deactivate one-half of the engine. This is accomplished by releasing the fulcrum point of the rocker arm, thereby allowing the valves to stay closed on the deactivated cylinders.

The kit also provides means for attaching the pushrod to the hydraulic lifter and furnishes a spring which holds the pushrod and lifter assembly up and away from the cam shaft while deactivated.

INSTALLATION INSTRUCTIONS

Typical Chevrolet V-8 • (Mechanical Systems Only)

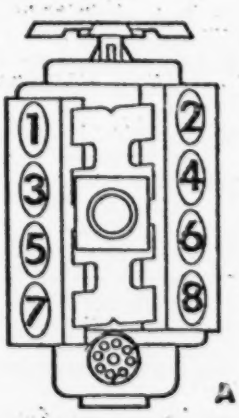
PREPARATION:

1. NOTE: This installation requires removal of the ignition distributor. If you don't know how to remove and replace it, get help either by referring to a service manual, or by talking with an experienced mechanic.
2. The top side of the engine should be cleaned, either with solvent or steam.
3. A set of rocker cover and intake manifold gaskets will be needed.
4. Special tool required, 1" HOLE SAW, with ¼" pilot drill and shank.

INSTALLATION:

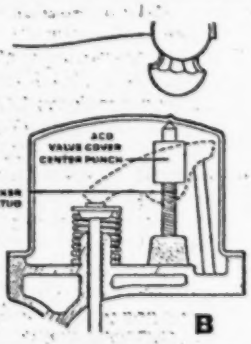
1. Disconnect ground cable clamp at battery terminal.
2. Drain coolant from radiator by opening drain cock on bottom radiator tank, or by removing bottom hose at radiator.
3. Before removing rocker arm covers, identify which cyldiners will be deactivated: Choose those with no access problems ON or OVER the rocker covers; that is, clear of OIL FILTER CAPS, PCV VALVE, MOUNT BRACKETS, or WIRING, ETC.
4. Remove rocker arm covers.
5. Remove ignition distributor, intake manifold, and all related lines, hoses, or wires. Use masking tape and felt pen to tag or mark any hoses, or wires, which might become mixed.
6. Remove rocker arms and pushrods for EVERY OTHER cylinder in the firing order: EITHER 1, 4, 6, 7; OR 8, 5, 3, 2. (See Ill. A.)

NOTE: Whichever cylinders you choose to deactivate, the combination should be as follows: on one bank, the FRONT and REAR cylinders will be affected; AND, on the other bank, the TWO CENTER cylinders. Pick a combination that will not interfere with the items listed in Step #3, above.



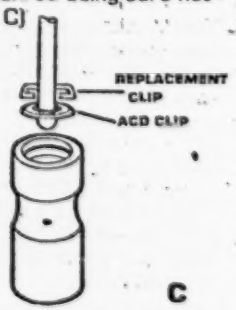
A

7. Remove the Adjusting nut, PIVOT BALL, and ROCKER ARM from the two STUDS of each of the affected cylinders. You may choose not to mix rocker assemblies, but if they are mixed by mistake, it is NOT critical. On BIG BLOCK Chevrolets, (396, 402, 427, 454 C1D) intake and exhaust pushrods are different lengths, but rocker assemblies are the same.
8. Remove the INTAKE AND EXHAUST lifters for each cylinder to be deactivated. Place on the bench, being as clean as possible. Remove the WIRE CLIP, PUSHROD CUP and flat disc from top of lifter. It is necessary to collapse the lifter for reassembly. You can do this by removing the inner plunger assembly and simply pouring out a portion of the oil underneath, OR, by depressing the ball check while pushing down on the plunger. You may now replace flat disc and pushrod cup. Do not install wire clip at this time.
9. Using a flat or triangular shape file, place a small groove 1/2" from top of pushrod. This is to help hold the ACD clip on the pushrod so it will not move.
10. Install Star clip onto a PUSHROD a distance of approximately 1/2" from the ball on the end. Slide 5/16" I.D. WASHER against CLIP and install SPRING onto PUSHROD. (See Ill. B)



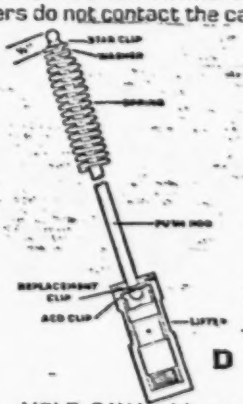
B

11. After completing all 8 PUSHROD/SPRING assemblies, the KIT is ready to install in the engine.
12. Install lifters into their respective holes in engine, without wire clips. Slide pushrod into hole above lifter.
13. Install ACD clip on ball of pushrod being sure not to distort ACD clip. (See Ill. C)
14. Push pushrod into lifter cup, down far enough to install wire clip (supplied with kit) into lifter groove on top of ACD clip. Repeat procedure on the other 7 lifter assemblies.



C

15. Re-install the intake manifold, ignition distributor, and all lines, hoses, and wires. DOUBLE CHECK all connections for proper routing.
16. Install ROCKER ARMS, PIVOT BALLS AND NUTS. For 4 cylinder operation, adjust valves with each CAM LOBE UP at its HIGHEST point. (Crank engine, watch pushrods—they should not move.) To operate in FOUR-CYLINDER mode, ROCKER ARMS are HELD UP so that the lifters do not contact the cam on the high side.
17. CLEAN ROCKER COVERS THOROUGHLY. INSTALL TRANSFER PUNCH on each ROCKER STUD to be deactivated, and mark ROCKER COVER (Tap with hammer) for 1" hole cutout. (See Ill. B)



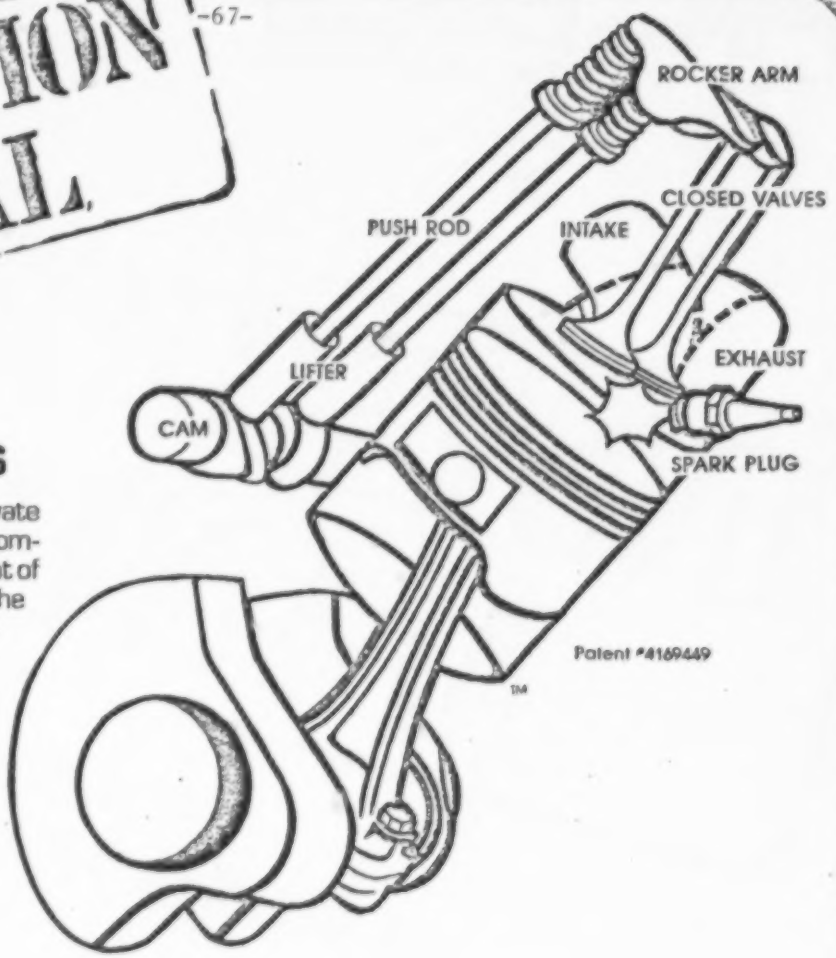
D

18. With the rocker cover held securely in a vise or bench clamp, align the PILOT DRILL of the 1" HOLE SAW with each PUNCH MARK; drill and cut out FOUR access holes. Remove all BURRS, inside and out, finishing with smooth half-round file or emery cloth. BE SURE NO METAL PARTICLES CAN FALL INTO ENGINE. Reinstall rocker covers.
19. To adjust ROCKERS for 8-CYLINDER operation, remove cup plugs in rocker covers, insert socket wrench, MAKING SURE cam lobe is DOWN. (This is most easily done by removing ignition distributor cap, and turning engine over until rotor points at spark plug wire location for that cylinder.) Then adjust as with a STOCK engine. Turn down adjustment nut until there is zero clearance. (Make sure you are not depressing lifter.) Advance nut 1/2 turn. This is the running adjustment.
20. For the BEST FOUR-CYLINDER economy and performance, tune to factory specification. If you have any specific tune-up problems or questions, contact ACDS inc. direct.

FOR MORE INFORMATION OR TO REORDER, WRITE TO: ACDS

1440 Hill St.
El Cajon, CA 92020
(714) 440-7385

INSTRUCTION MANUAL



HOW IT WORKS

The purpose of this kit is to deactivate one-half of the engine. This is accomplished by releasing the fulcrum point of the rocker arm, thereby allowing the valves to stay closed on the deactivated cylinders.

The kit also provides means for attaching the pushrod to the hydraulic lifter and furnishes a spring which holds the pushrod and lifter assembly up and away from the cam shaft while deactivated.

INSTALLATION INSTRUCTIONS

Typical Chevrolet V-8 • [Mechanical Systems Only]

PREPARATION:

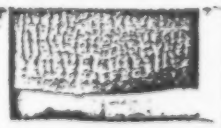
1. NOTE: This installation requires removal of the ignition distributor. If you don't know how to remove and replace it, get help either by referring to a service manual, or by talking with an experienced mechanic.
2. The top side of the engine should be cleaned, either with solvent or steam.
3. A set of rocker cover and intake manifold gaskets will be needed.
4. Special tool required: 1 1/8" HOLE SAW, with ¼" pilot drill and shank.

ACDS INC™
RESEARCH & DEVELOPMENT

INSTRUCTION MANUAL

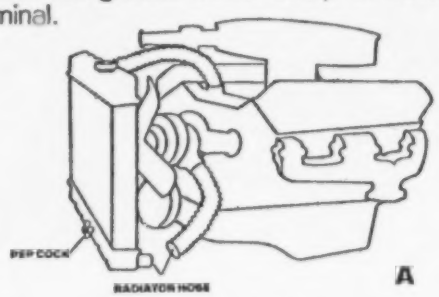
FOR INSTALLATION OF MECHANICAL ACD SYSTEM ON SMALL AND BIG BLOCK CHEVROLETS

"AUTOMOTIVE CYLINDER DE-ACTIVATOR SYSTEM"



INSTALLATION:

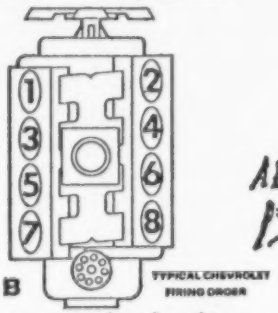
1. Disconnect ground cable clamp at battery terminal.



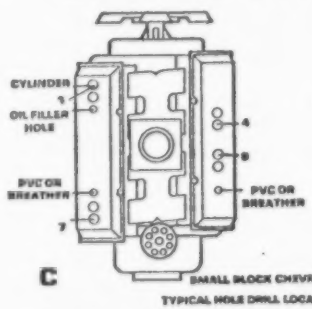
A

2. Drain coolant from radiator by opening drain cock on bottom radiator tank, or by removing bottom hose at radiator. [See Ill. A]

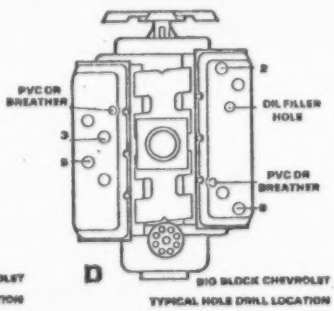
3. Before removing rocker arm covers, identify which cylinders will be deactivated: 1, 4, 6, 7 or 2, 3, 5, 8. Choose those with no access problems ON or OVER the rocker covers; that is, clear of OIL FILTER CAPS, PCV VALVE, MOUNT BRACKETS, or WIRING, etc. [See Ill. B]



B



C

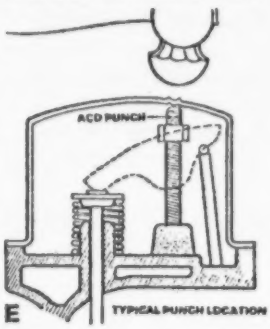


D

NOTE: Whichever cylinders you choose to deactivate, the combination should be as follows: on one bank, the FRONT and REAR cylinders will be affected; AND, on the other bank, the TWO CENTER cylinders. Pick a combination that will not interfere with the items listed in Step #3, above. [See Ill. C and D]

4. Remove rocker arm covers. CLEAN ROCKER COVERS THOROUGHLY. INSTALL TRANSFER PUNCH on each ROCKER STUD to be deactivated, and mark ROCKER COVER [Tap with hammer] for 1 1/8" hole cutout. [See Ill. E] With the rocker cover held securely in a vise or bench clamp, align the PILOT DRILL of the 1 1/8" HOLE SAW with each PUNCH MARK; drill and cut out FOUR access holes. Remove all BURRS, inside and out, finishing with smooth halfround file or emery cloth. BE SURE NO METAL PARTICLES CAN FALL INTO ENGINE. Reinstall rocker covers.

After 13



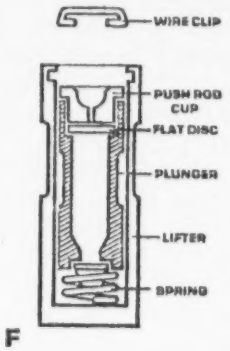
E

5. Remove ignition distributor, intake manifold, and all related lines, hoses, or wires. Use masking tape and felt pen to tag or mark any hoses, or wires, which might become mixed.

6. Remove Rocker Arms and Pushrods from cylinders to be deactivated.
Remove the Adjusting nut, PIVOT BALL, and ROCKER ARM from the two STUDS of each of the affected cylinders. You may choose not to mix rocker assemblies, but if they are mixed by mistake, it is NOT critical. On BIG BLOCK Chevrolets, [396, 402, 427, 454 C1D] intake and exhaust pushrods are different lengths, but rocker assemblies are the same.

7. Remove the INTAKE AND EXHAUST lifters for each cylinder to be deactivated. Place on

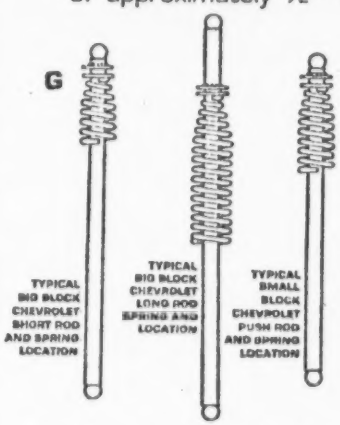
the bench, being as clean as possible. Remove the WIRE CLIP, PUSHROD CUP and flat disc from top of lifter. It is necessary to collapse the lifter for reassembly. You can do this by removing the inner plunger assembly and simply pouring out a portion of the oil underneath, OR, by depressing the ball check while pushing down on the plunger. You may now replace flat disc and pushrod cup. Do not install wire clip at this time. [See Ill. F]



F

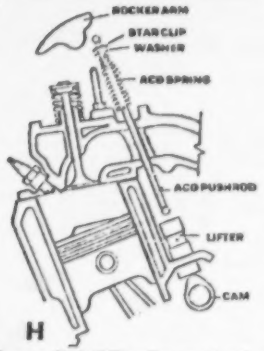
8. Install ACD clip onto a PUSHROD a distance of approximately ½" from the ball on the end. Slide 5/16" I.D. WASHER against CLIP and install SPRING onto PUSHROD. [See Ill. G] [This is pre-installed at ACDS factory but must be checked.]

NOTE: Big Block Chevrolet clip to be 1 5/8" from top of Long Rod. Short Rod ½" from top.

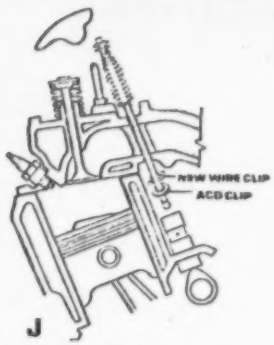

TYPICAL BIG BLOCK CHEVROLET SHORT ROD AND SPRING LOCATION
TYPICAL BIG BLOCK CHEVROLET LONG ROD SPRING AND LOCATION
TYPICAL SMALL BLOCK CHEVROLET PUSH ROD AND SPRING LOCATION
G

9. After completing all 8 PUSHROD/SPRING assemblies, the KIT is ready to install in the engine.

10. Install lifters into their respective holes in engine, without wire clips. Slide ACD pushrod, with springs installed, into hole above lifter. [See Ill. H]



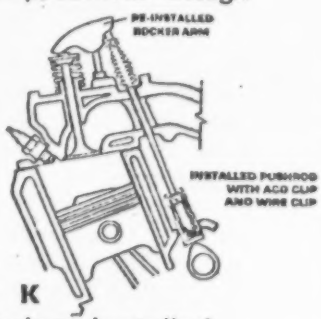
H



J

Install ACD clip on ball of pushrod, being sure not to distort ACD clip. [See Ill. J] CUP UP

11. Push pushrod into lifter cup, down far enough to install wire clip (supplied with kit) into lifter groove on top of ACD clip. [See Ill. K] Should be inserted after clip. Repeat procedure on the other 7 lifter assemblies. [See Ill. K]



K

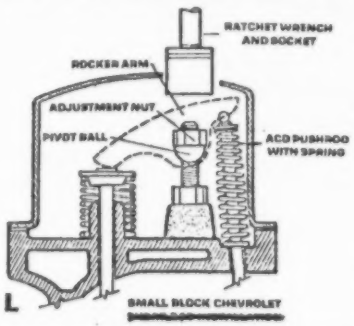
NOTE: Big Block Chevrolet Long Spring installed under Pushrod Guide. Short Spring installed on top of Pushrod Guide. [See Ill. M and N, on back]

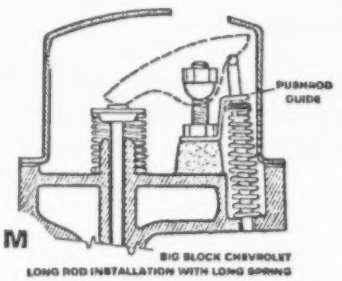
12. Re-install the intake manifold, ignition distributor, and all lines, hoses, and wires. DOUBLE CHECK all connections for proper routing.

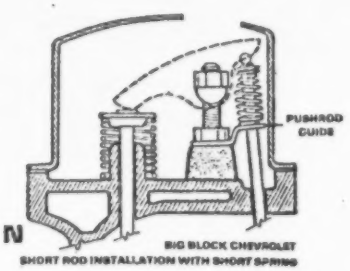
13. Install ROCKER ARMS, PIVOT BALLS AND NUTS. For 4 cylinder operation, adjust valves with each CAM LOBE UP at its HIGHEST point. [Crank engine, watch pushrods—they should not move.] To operate in FOUR-CYLINDER mode, ROCKER ARMS are HELD UP so that the lifters do not contact the cam on the high side. [See Ill. L on back]

14. To adjust ROCKERS for 8-CYLINDER operation, remove cup plugs in rocker covers, insert socket wrench, MAKING SURE cam lobe is DOWN. [This is most easily done by removing ignition distributor cap, and turning engine over until rotor points at spark plug wire location for that cylinder.] Then adjust as with a STOCK engine. Turn down adjustment nut until there is zero clearance. [Make sure you are not depressing lifter.] Advance nut ½ turn. This is the running adjustment. [See Ill. L, M and N]

15. For the BEST FOUR-CYLINDER economy and performance, tune to factory specification. If you have any specific tune-up problems or questions, contact ACDS Inc. direct.







TROUBLE-SHOOTING

CONDITION	CAUSE	CORRECTION
Noisy on 4-cylinders	1. Valves, deactivated, still contacting cam shaft 2. Loose timing chain	1. Loosen adj. nuts until all deactivated valve lifters do not contact cam shaft 2. Replace chain and gears
Noisy on 8-cylinders	1. Improper valve adjustment	1. Recheck and correct adjustment
Rough idle on 4-cylinders	1. Idle speed too slow 2. Vacuum leaks 3. Improper idle adjustment 4. Improper timing adjustment	1. Raise speed until smooth 2. Check all hoses and connections; replace as necessary 3. Adjust idle mixture screws 4. Adjust timing
Rough idle on 8-cylinders	1. All of above on 4-cylinder model 2. Tight valves	1. Same 2. Recheck and correct
Stalls at stop light on 4-cylinders	1. Idle too slow in gear or operating Air Conditioner while in gear	1. Raise idle
Runs too rich on 4-cylinders	1. Dirty carburetor [choke sticking, etc. 2. Jets in carb. too large	1. Clean carburetor and correct all adjustments 2. Replace with smaller jets
Hard start on 4-cylinder [cold]	1. Choke not functioning 2. Needs tune-up	1. Repair choke 2. Tune engine
Hard start on 4-cylinder [hot]	1. Flooding 2. Needs tune-up	1. Do not pump accelerator 2. Check condition of carb. plugs, etc.

- Federal law requires that no changes be made to your pollution control equipment.
- For "Flip of a Switch" convenience on your Chevrolet, your Mechanical ACD System can be converted to a hydraulic system at a later date.

FOR MORE INFORMATION OR TO RE-ORDER, WRITE TO:

ACDS INC.™
RESEARCH & DEVELOPMENT
1440 HILL ST., EL CAJON, CA 92021 (714) 440-7585

ACOS INC.™
RESEARCH & DEVELOPMENT
1440 HILL STREET • EL CAJON, CA 92021 • (714) 440-7585

DRIVING TEST: *

GAS

1977 CHEVROLET EL CAMINO
LICENSE NO. (ARIZ.) 2SA031
350 CUBIC INCH ENGINE — AUTOMATIC TRANSMISSION

BEFORE ACOS 55 - 60 m.p.h.

SPEEDOMETER	PLACE	MILES	GALS.	M.P.G.
72.3 - 261	Phoenix/Ehrenberg, AZ.	188.7	12.6	14.98
261.0 - 1256.3	Local runs	995.3	82.1	12.12
1256.3 - 3805	Ehrenberg/Winner, S. Dakota	2548.7	165.52	15.40
3805.0 - 5396	Winner/San Diego	1591.0	105.1	15.14

5323.7 MILE AVERAGE = 14.41 MPG

WITH ACOS 55 - 60 m.p.h.

5524/5635	Ehrenberg/Buckeye	111	4.3	25.81
5710/6010	Phoenix/Blythe and local	300	12.3	24.39
8177/8277	Blythe/El Centro	100	4.3	23.26
8894/9306	Ehrenberg/Showlow	412	18.1	22.76
9306/9630	Showlow/Vaughn, N. Mex. (high altitude - made change)	324	20.0	16.20
9630/9776	Vaughn/Muleshoe, Texas	146	5.1	28.63
9776/10222	Muleshoe/Belton, Texas	446	18.0	24.78
10448/10810	Temple/Odessa, Texas (wind and air cond.)	362	20.3	17.83
10810/11075	Odessa/El Paso (8 cyls. - wind)	265	17.0	15.58
11075/11385	El Paso/Tucson (wind)	310	17.1	18.13
11385/11627	Tucson/Yuma (rain)	242	10.8	22.41
11627/11815	Yuma/San Diego (wind & rain)	188	10.6	17.74
11815/12321	San Diego/San Jose	506	21.8	23.21

6797 MILE AVERAGE = 21.59 MPG

AN INCREASE OF 49.8%

This information compiled under all kinds of driving conditions — the test with the ACOS was conducted with the engine run on 4 & 8 cylinders depending on the needs of the auto at the time.

WITH ACOS AND TURBO
65 - 70 m.p.h.

46051	Round Trip, San Diego/Muleshoe/San Diego	2398	91.3	26.26

*Actual Test Data On File At:

ACOS INC.

Attachment C-2

ACDS INC.™
RESEARCH & DEVELOPMENT
1440 HILL STREET • EL CAJON, CA 92021 • (714) 440-7585

DRIVING TEST* GAS*

1970 Ford Van
302 Cubic Inch engine
3-speed standard transmission

6/12/79 Trip from El Cajon, California to Hendersonville, N.C. and return trip by way of Wasco, California and Tacoma, Washington.
154172 miles on engine at installation of ACD system.

PLACE	GALS.	MILES
El Cajon, Ca. to Yuma, Arizona	6.1	155
Yuma, Arizona to Benson, Arizona	15.2	284
Benson, Arizona to Deming, N.M.	11.3	168
Deming, N.M. to Pecos, Texas	14.6	312
Pecos, Texas to Abilene, Texas	15.5	251
Abilene, Texas to Texarkana, Texas	15.9	356
Texarkana, Texas to Forest City, Ark.	18.5	327
Forest City, Ark. to Murfreesboro, Tenn.	13.3	293
Murfreesboro, Tenn. to McMinnville, Tenn.	5.4	
McMinnville, Tenn.	13.3	
McMinnville, Tenn.	11.4	753
McMinnville, Tenn. to Hendersonville, N.C.	11.0	269
Hendersonville, N.C. to McMinnville, Tenn.	13.3	286
McMinnville, Tenn.	11.0	154
McMinnville, Tenn. to Forest City, Ark.	11.6	383
Forest City, Ark. to Oklahoma City	12.3	253
Oklahoma City to Shamrock, Texas	17.6	
Shamrock, Texas to New Mexico	15.9	692
New Mexico to Winslow, Arizona	16.2	295
Winslow, Arizona to Needles, Arizona	12.0	265
Needles, Arizona to Wasco, Calif.	12.4	314
Wasco, Calif. to Sacramento, Calif.	14.1	
Sacramento, Calif. to Ashland, Oregon	16.6	
Ashland, Oregon to Tacoma, Wash.	9.0	1034
Tacoma, Wash. to Burg, Oregon	14.7	323
Burg, Oregon to Redding, Calif.	12.1	
Redding, Calif. to Stockton, Calif.	10.0	
Stockton, Calif. to Wasco, Calif.	12.6	712
Wasco, Calif. to El Cajon, Calif.	13.7	278
TOTAL GAS USED and TOTAL MILES TRAVELED	376.6	8,157

AVERAGE PER GAL. 21.6

This information compiled under all kinds of driving conditions and the speed ranged from 55 to 60 mph. The test with the ACD was conducted with the engine running on 4 & 8 cylinders depending on the needs of the auto at the time.

Actual Test Date On File At:

ACDS INC.

Form #79004H

Attachment C-3

ACDS INC.™
RESEARCH & DEVELOPMENT
1440 HILL STREET • EL CAJON, CA 92021 • (714) 440-7585

DRIVING TEST*

*GAS

1970 FORD VAN
302 cubic inch engine
3-speed standard transmission

6/8/79 Trip from San Diego to Murfreesboro Tenn.
154172 miles on engine at installation of ACDS system

PLACE	GALS.	MPH
San Diego to Benson Arizona	20.3	55-60
Benson Arizona to Deming N.M. (strong winds)	13.6	55-60
Deming N.M. to Pecos Texas	14.3	55-60
Pecos Texas to Abilene Texas	14.0	55-60
Abilene Texas to Texarkana Ark.	14.3	55-60
Texarkana Texas to Murfreesboro Tenn.	30.5	55-60
TOTAL GALS.	107	

TOTAL MILES TRAVELED 2,146

AVERAGE PER GAL. 20.5

This information compiled under all kinds of driving conditions — the test with the ACDS was conducted with the engine run on 4 & 8 cylinders depending on the needs of the auto at the time.

*Actual Test Data On File At:
ACDS INC.

Attachment C-4

ACDS INC.™
RESEARCH & DEVELOPMENT
1440 HILL STREET • EL CAJON, CA 92021 • (714) 440-7585

DRIVING TEST: *

DIESEL

1973 KW3 AXEL TRACTOR
350 CUMMINGS DIESEL 6 CYLINDER ENGINE

THIS TRACTOR WAS EQUIPPED WITH A PROTOTYPE ACDS FOR THE DIESEL ENGINE ON TESTS CONDUCTED OVER A DISTANCE OF 1000 MILES, PULLING A 45'-0" REFRIGERATED TRAILER ON 3 CYLINDERS. THERE WAS A SAVINGS OF 25-30% ON DIESEL FUEL CONSUMPTION!!*

*Actual Test Data On File At:
ACDS INC.

ACOS INC.™
RESEARCH & DEVELOPMENT
1440 HILL STREET • EL CAJON, CA 92021 • (714) 440-7585

DYNO TESTING: *

GAS

1978 FORD THUNDERBIRD
LICENSE NO. (CAL.) 295UXY
400 CUBIC INCH ENGINE — AUTOMATIC TRANSMISSION
TEST LAB VEHICLE NO. CH0026
TEST CONDUCTED BY AN INDEPENDENT TESTING LABORATORY.

RUNNING ON 8 CYLINDERS:

	HC	CO	CO2%	NOX	NOXC	MPG
HIWAY FUEL ECONOMY GRAMS-DF	34.604	379.840	6968.862	8.010	7.649	11.784
HIWAY FUEL ECONOMY GMS/MI	3.392	37.239	683.221	0.785	0.749	11.784

RUNNING ON 4 CYLINDERS:

	HC	CO	CO2%	NOX	NOXC	MPG
HIWAY FUEL ECONOMY GRAMS-DF	8.463	302.958	4689.336	19.541	18.485	17.421
HIWAY FUEL ECONOMY GMS/MI	0.829	29.701	459.738	1.915	1.812	17.421

(All Figures Are Parts Per Million Measure.)

ALL EMISSIONS DROPPED SUBSTANTIALLY WHEN THE WAS SWITCHED FROM 8 TO 4 CYLINDERS!!

AND THE MPG INCREASED 48% OR 5.6 MPG!!

AND THE MPG INCREASED 48% OR 5.6 MPG!!

This information was compiled under the same testing time and conditions.

*Test Data On File At:
ACOS INC.

Attachment C-6

ACDS INC.™
RESEARCH & DEVELOPMENT
1440 HILL STREET • EL CAJON, CA 92021 • (714) 440-7585

July 30, 1979

On July 14, we left San Diego on a five thousand mile trip.

I was accompanying Mr. Don Mitchell, a Vice President of ACDS, whom I have known for many years.

Although I was impressed with the possibilities the ACD possessed I naturally had some reservations as to the over-all success of such a venture on an extended trip. Being a builder of race cars and knowing a lot about the mechanical end of things, I was extremely curious to see exactly what problems we would run into.

According to the car's log, I noted that before the installation of the ACD, the best mileage attained was 10.4 miles per gallon.

We spent four days and three nights on the first 2,100 mile leg of the journey, driving as much as 700 miles in one day, running the air conditioner about 85% of the time. We ran almost entirely on four cylinders, switching to eight cylinders on some of the steeper inclines through the Rockies. We even encountered a tornado in Wyoming, and of course had to run on eight cylinders through the 60 to 70 mile per hour head winds. We arrived in St. Paul with no mechanical difficulties and still had ⅔'s of our sixth tank of gas left in the car. We were averaging a little over twenty miles per gallon. I have to tell you, it was a pleasure to drive right on past the lines of cars waiting for gas at the many stations across the country.

By now, I was naturally very impressed with the performance and of course all the potential that lay in store for such an invention.

The interest at the show we attended was fantastic. Everyone we spoke with wanted more information, and about 75% of the people thought the idea was the greatest thing to come along in a long time.

The 1978 Thunderbird we drove had a "Test Car" sign on the side indicating 4/8 cylinder power. This generated an interest with the CB's you wouldn't have believed. We were kept busy constantly explaining the purpose, and we were requested to pull over on several different occasions to pass out literature, etc. The interest was really something else.

We added one quart of oil about the last 1,000 miles of the trip, which I considered excellent, due to the extreme heat and weather conditions we were driving through.

In addition to driving on four cylinders over the freeways and interstates, we also drove almost entirely on four cylinders through all of the bigger cities during traffic rush hours [Chicago, St. Paul, St. Louis, Phoenix, etc.].

The trip ended with our return to San Diego on July 27, with a grand total of 5,008 miles and an over-all average of 17.5 miles per gallon. [This figure includes all town driving, plus four days of demonstrations at the show.]

I repeat myself in saying that I am totally impressed with this device. I definitely want one installed on my own vehicle, and I would recommend one to anyone who wants to drive a heavy comfortable American made car. Why not drive a luxurious car with all of the comforts and still get the same gas economy as a small cramped foreign model.

Keith Kleinkopf

Keith Kleinkopf
Retired Electrical Contractor
Hornbrook, California

Item #12

PACETEC -79- ASSOCIATES

Attachment C-7

382 LARCH CREST COURT
THOUSAND OAKS, CALIFORNIA 91360

PHONE: 805-382-5468
805-498-5317

Mr. Don Mitchell
Vice President Marketing
ACDS, Incorporated
1440 Hill Street
El Cajon, CA 92020

Dear Don:

A technical report documenting the driving tests for the 1978 Ford Thunderbird is enclosed. The report is impartial and can be considered to be your property to use at your discretion.

A cost breakdown for conducting the test appears in the attached billing.

There are a number of packaging improvements that would make the final product more marketable. I realize that many of these ideas may have already occurred to you, but here are a few for your consideration:

1. Rigid valve covers with ACDS hydraulic manifolds and pistons pre-installed on the new valve covers for each model car.

2. Complete set of power steering hoses with single "T" fittings to the power steering pump of each model car, for easy installation.

3. One hydraulic solenoid valve located near the power steering pump, rather than two valves presently used. This would reduce production costs and maintenance.

Should you have any questions regarding this report, please do not hesitate to contact me.

Best regards,

Mike Slaminski

J. M. Slaminski

AUTOMOTIVE CYLINDER DEACTIVATION SYSTEM

FUEL ECONOMY DRIVING TESTS

FORD THUNDERBIRD

Prepared For

ACDS, Incorporated
1440 Hill Street
El Cajon, CA 92020

PACETED Associates
382 Larch Crest Court
Thousand Oaks, CA 91360

September 1979

INTRODUCTION

Fuel efficiency driving tests were performed on a 1978 Ford Thunderbird to determine the fuel saving effectiveness of the Automotive Cylinder Deactivation System (ACDS) installed on the test car. A description of the test car and equipment related to fuel efficiency is given in the following list:

1978 Ford Thunderbird
Body # F8J87S124951F
400 Cubic Inch Engine
Air Conditioner
Power Steering
Power Brakes
Power Windows
ACDS Fuel Saving Device
On-Board Computer with Fuel Flow Meter

The on-board computer displayed all information necessary to obtain fuel efficiency data during driving tests:

1. Instantaneous Fuel Efficiency(3 Second mpg Averages).
2. Distance Traveled (miles).
3. Fuel Consumption (gallons).
4. Mean Fuel Efficiency (mpg for Distance Traveled).
5. Fuel Cost (¢/mile).

Computer outputs 2 and 3 were verified with odometer readings and purchased fuel quantities, respectively.

Driving tests designed to analyze the fuel efficiency effectiveness of the ACDS under conditions typically encountered in urban and suburban areas were conducted:

1. Extended Freeway/City Driving (Table 1) -- Computer Accuracy Verification.
2. Highway Driving Test (Table 2).
3. City Driving Test (Table 3).

The driving test series was conducted between August16 and September 4, 1979.

EXTENDED FREEWAY/CITY DRIVING TEST

The results of the Extended Freeway/City Driving Test are tabulated in Table 1. Tests were not conducted between August 16 and August 21 due to a fuel leak in a fuel line at the fuel flow meter, and the car was inoperative between August 25 and August 29 because of a dead battery drained by an electrical short near the alternator.

The computer/flow meter combined accuracy is well within the 1-2 gallon variation in topping the fuel tank. The filler neck of this particular tank made it difficult to be certain that the tank was actually full, since the fuel level is hidden from view.

The difference between the computer fuel consumption and purchased gasoline quantities ranges from 0.1 - 1.7 gallons in Table 1. The average variation in purchased gasoline relative to computer results was +8%, and the best comparison was less than a 1% differential. Computer distance and oddometer readings compared within 1.5% in Table 1. Therefore, it was concluded that the computer fuel efficiency (mpg) values were within ±10%, and probably much better considering the variations in topping the tank.

Only the first two tests in Table 1, those conducted between August 21 - 23 and August 23 - 25, yielded comparable results for the 4 & 8 cylinder operating modes. The ACDS device exhibited a 31% increase in fuel efficiency during those first two tests.

It will be seen in later sections of this report that the many accelerations associated with city driving consumes fuel at a very high rate, radically depressing overall fuel efficiency. Unfortunately, considerable city type driving was necessary during the third test series (August 29 - August 1), and both 4 and 8 cylinder operating modes had to be used during the fourth test series (September 1 - September 3) with many accelerations on and off the freeway. Consequently, the third and fourth tests could not be used as a measure of the ACDS effectiveness.

The fifth test run in Table 1 was accomplished the last day before returning the test car; it was of relatively short distance, but the test does indicate that substantial fuel efficiency increases (36%) are possible with the ACDS device.

HIGHWAY DRIVING TEST

Highway Driving Test results are listed in Table 2 in the form of 3 second computer fuel efficiency (mpg) ranges for carefully selected constant grade stretches of the Ventura Freeway. At least two test runs were made for each entry shown in the Freeway Condition column (Table 2). The test runs demonstrated an amazing degree of consistency, with near exact duplication of fuel efficiency outputs on repetition of each run. Consequently, there is a very high confidence level in the test results in Table 2.

The ACDS device conclusively demonstrates that a 17 - 42% increase in highway fuel efficiency is possible in 4 cylinder operation, over a wide variety of roadway grade circumstances. Most highway fuel efficiency results are as expected in Table 2, with upgrade fuel efficiencies being lower than downgrade and level values, and that fuel efficiency is inversely proportional to the steepness in grade. The ACDS device saves fuel under nearly all high speed road conditions (except possibly exceedingly steep grades) as it is presently configured in the test car.

It is interesting to note that the largest percentage increase in fuel efficiency (42%) occurs in the moderate upgrade freeway condition, while the larger increment in fuel efficiency (5.5 mpg) is realized for the level situation. The explanation for this is that the load on the engine in the moderate upgrade situation lies below the maximum 4 cylinder power curve at medium RPM, yielding about the same savings in fuel consumption as the level test (5.0 versus 5.5 mpg), but the improvement is realized at a reduced magnitude in fuel efficiency.

CITY DRIVING TEST

Results from the City Driving Test are shown in Table 3, in the form of computer fuel efficiency averages. The data is shown to be highly repeatable in multiple test runs. A 7.3 mile course in the City of Thousand Oaks, California was selected to provide a mixture of heavily traveled sections with closely spaced traffic lights, and lightly traveled sections with few traffic lights.

The ACDS 4 cylinder operation was used only when the automatic transmission was in high range, that is, 8 cylinder operation was used for acceleration to cruising speed. Four (4) cylinder operation was judged to be unsafe in city traffic situations requiring rapid acceleration.

The ACDS did not result in any noticeable fuel efficiency improvement (within the 1% computer truncation error) during city driving conditions. This is probably due to the overpowering appetite for fuel on acceleration, relative to the small anount required for cruise and coasting situations.

CONCLUSIONS

The ACDS fuel saving device is the most effective conservation retrofit system for automobiles available today. Up to 42% improvement in fuel efficiency in terms of mpg can be realized in highway driving. The ACDS breakthrough is most effective for those autos driven a high percentage of time on freeways or highways. There is no reason for the system to cause any damage to the engine since the device simply raises the valve rocker arm above the valve push rod stroke.

The 4 cylinder operating mode of the ACDS device is sluggish during low speed acceleration, and it is not recommended for most city driving situations. In addition, improvement in fuel efficiency in city driving is negligible for all practical purposes.

TABLE 1. HACETEC PERFORMANCE TEST
For
ACOS, INCORPORATED

1978 FORD THUNDERBIRD
BODY # F8J87S12475IF
400 in³ ENGINE

DATES (1979)	TRAVEL POINTS	ENGINE CONFIGURATION	ODOMETER DISTANCE (miles)	GASOLINE PURCHASED (gal)	Mileage (mfg)	COMPUTER OUTPUTS		
						DISTANCE (miles)	GASOLINE USED (gal)	MILEAGE* (mfg)
8/[illegible]-8/[illegible]	El Monte → Traveling Col; To Cal Poly Pomona + Local (2/3) To → El Monte	4 cyl	241.5	18.5	13.34	Unavailable	Unavailable	Unavailable
8/22-8/[illegible]	El Monte → To To → Huntington Beach +13% Local	8 CYL	230.9	19.2	12.03	25[illegible].1	[illegible].8	12.7
8/21 - 8/[illegible]	El Monte → To To ↔ El Monte** +15% [illegible]	4CYL	191.2	14.4	11.52	192.2	14.[illegible]	13.3
9/1 - 9/3	Fuel Economy Tests† To ↔ Ontario +~5% Local	60% 4 CYL 40% 8 CYL	195.5	14.7	13.2	187.8	14.6	13.0
9/4	To → El Monte	4 CYL	—	—	—	53.9	3.1	17.3

* Amount Computed by Computer Integration
** Heavy Traffic Required Periods of Additional City Driving
† Stop & Go Driving Between Test Runs

FUEL ECONOMY TEST – HIGHWAY
For
ACOS, INCORPORATED

1978 FORD THUNDERBIRD
BODY # F8J8Z1249511F
400 in³ ENGINE

DATE	FWY CONDITION	3 SECOND COMPUTER OUTPUTS		% INCREASE
		4 CYL MILEAGE (mpg)	8 CYL MILEAGE (mpg)	
9/1	Level & Flat	[illegible] [21.5]	14-18 [16]	[illegible]
9/1	Moderate Upgrade	16-18 [17]	11-13 [illegible]	42%
9/1	Moderate Downgrade	35-36 [35.5]	18-24 [21]	[illegible]
9/1	Steep Upgrade	11-12* [11.5]	7-12 [9.5]	21%
9/1	Steep Downgrade	56-94 [75]	55-75 [64]	17%

[ ] – Bracketed Values Are Numerical Averages

Test Conditions:

1. Cruise Control Set At 60mph
2. A/C On
3. Level Test – Ventura Fwy Vicinity Woodland I
4. Moderate Grade – Ventura Fwy Karmen Rd
5. Steep Grade – Ventura Fwy Calabasas Grade
6. Two(2) Test Runs For Each Condition
7. Duplicate Results Occurred For Each Repetiti
8. All Grades Near Constant
9. Engine At Operating Temperature

* 60 mph Speed Decreased To ~50mph

Attachment D

AESi...!
AUTOMOTIVE ENVIRONMENTAL SYSTEMS, INC. ■ 7300 BOLSA AVENUE WESTMINSTER, CALIFORNIA 92683 ■ 714-897 0333
A subsidiary of Clayton Manufacturing Company

Item #13

June 8, 1979

Tom Rogers
HER Industries
1440 Hill Street
El Cajon, CA 92021

Dear Mr. Rogers:

It has been a pleasure to assist you and your company by performing these emissions tests and hope that we may be of help in any future testing programs that you may have.

The results of these tests, tabulated on the accompanying sheet, are expressed in the following units of measure: hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), and oxides of nitrogen corrected for humidity (NOxC), are all expressed in grams per phase and total grams of pollutant per vehicle mile. The fuel consumption, expressed in miles per gallon (MPG), is calculated from the mass emission data using the carbon atom balance technique.

AESi's testing laboratory is checked daily to ensure continued certification for on-going EPA contract testing.

The vehicles were operated through an EPA prescribed dynamometer driving schedule for preconditioning before performing each test. The tests were performed on commercial grade gasoline.

The Hot Start LA-4 tests were based on the Federal Emission Certification Test Procedure as generally described in the Federal Register Part 86, Subpart B. The Highway Fuel Economy Test is described in the Federal Register Part 600. All calculations and data reporting are based on the Federal Test Procedure.

AESi

AUTOMOTIVE ENVIRONMENTAL SYSTEMS, INC.

Tom Rogers
HER Industries
June 8, 1979

page 2

The source documents supporting the attached test data presentation are enclosed. The computer printout for the Thunderbird was provided to you following its test. No changes to that printout were necessary as a result of our quality assurance check. The test on the Cadillac required some recalculations and the corrected copy of the printout is enclosed. AESi will retain and safeguard the original of the computer printout should any questions arise.

The results from these tests are only applicable to the specific test vehicles and may not be extrapolated to the vehicle population in total. No conclusions should be drawn from these test results, other than as they pertain to the specified vehicles tested. You are reminded of the Testing Agreement restrictions not to use AESi's name or letter of results or parts thereof in connection with any advertising or sales promotion without prior written approval from an officer of AESi.

AESi looks forward to having the opportunity of serving you again, and if you have any questions regarding these tests, please feel free to contact me.

Sincerely,

Lawrence L. Moore

Lawrence L. Moore, Director
Research & Testing Programs

LLM:mra

Attachment

AESi
AUTOMOTIVE ENVIRONMENTAL SYSTEMS, INC.

EXHAUST EMISSIONS TESTS
CONDUCTED FOR HER INDUSTRIES

June 8, 1979

Vehicle Description

Year:	1978	VIN:	8J87S124951
Make:	Ford	Displacement:	400 CID
Model:	Thunderbird	Transmission:	Automatic

Test No. 1 (May 31, 1979)

Highway Fuel Economy test with commercial grade gasoline. Four cylinders disengaged.

HC	CO	CO_2	NOx	NOxC	MPG
0.829	29.701	459.738	1.915	1.812	17.421

Test No. 2 (May 31, 1979)

Highway Fuel Economy test with commercial grade gasoline. Normal eight cylinder operation.

HC	CO	CO_2	NOx	NOxC	MPG
3.392	37.239	683.221	0.785	0.749	11.784

Certified: June 8, 1979

Lawrence L. Moore

Lawrence L. Moore, Director
Research & Testing Programs

LLM:mra

October 31, 1979

Mr. Thomas B. Rogers
President, ACDS. Inc.
1440 Hill Street
El Cajon, California 92021

Dear Mr. Rogers:

This is in response to your September 26, 1979 submission of an application under Section 511 of the Motor Vehicle Information and Cost Savings Act for evaluation of the "Automotive Cylinder De-Activator Systems" as a fuel economy retrofit device.

The purpose of this letter is to request clarification of several points made in the application. Upon successful resolution of these points, a schedule for confirmatory testing at the Environmental Protection Agency, Motor Vehicle Emission Laboratory (MVEL) will be arranged. The points in question are given below:

1. Applicability of the Device: From the description given in the patent, several different versions of the device exist. Which unit is sold for what vehicle? Can four cylinder push rod vehicles use the device? Can vehicles without power steering pumps use the device? Several makes of vehicles do not have stud rocker arm fulcrums but have a common shaft. Is your device applicable to these vehicles? It appears that the device as described is not applicable to all push rod style engines. Please submit a more complete listing of applicable vehicles, precluding vehicular descriptors, and designate which valve lifter mechanism, push rod extender, etc. apply to which vehicles. What about vehicles with "solid" lifters or roller cams?

2. Description of the Device: The description given in the patent is sufficient if it is the device your are planning on marketing. The installation instructions indicated a different valve lifter mechanism than the patent. Please specify which product is to be marketed, and supply sketches and/or diagrams of this product. If the current production model varies from the patent please specify what changes have been made. Please explain how release valve #100 as shown in your patent application is activated by the vehicle operator.

3. Device Installation: The installation instructions are unclear and referenced photographs were not included. The instructions should be more specific to the applicable vehicle. Please submit more precise installation instructions including those used on the AESI test vehicles. Please specify approximate time and cost of installation.

4. Device Operation: Please explain how the device is to be used. Should it only be used in highway driving or does its usage include city driving? How are the control valves activated?

5. Device Maintenance: How are the valve lash (both solid lifter and hydraulic lifter initial setting) adjustments affected by installation of your device? Do hydraulic lifters continue to operate properly with this system?

6. Effects on Vehicle Emissions (non-regulated): The application for evaluation does not address the issue of non-regulated emissions. The attached test results only specify regulated emissions.

7. The AESi Test Results: These results, while impressive, have several missing pieces of information, including:

   a. Complete vehicle description, including odometer reading and date of each test.

   b. Vehicle parameter adjustments. Were any changes made to the timing, F/A ratio etc. during installation of your device? Please furnish a complete history of the device testing including baseline testing. The Highway Fuel Economy Test Numbers for the eight cylinder engine testing are quite low. Do you have any rationale to explain this?

   c. No Federal Test Procedure testing data was presented. Why not?

   d. Where is the Hot Start LA-4 Test data? Please supply copies of the AESi printout.

   e. Test data is supplied for only one vehicle, yet the AESi letter refers to both a Cadillac and a Thunderbird.

Please submit all test data on the device.

Because of these questions, testing at EPA cannot be scheduled at this time. If you have any questions concerning this matter, please contact Mr. Thomas Penninga of my staff at 313-668-4477.

Sincerely,

Charles L. Gray, Director
Emission Control Technology Division

CLG

ECTD:TAEB:GRAY:mc:X325:2565PlymouthRd:10/31/79

Attachment F

ACOS INC.™
RESEARCH & DEVELOPMENT
1440 HILL STREET · EL CAJON, CA 92021 · (714) 440-7585

November 27, 1979

Mr. Charles L. Gray, Director
Emission Control Technology Division
United States Environmental Protection Agency
Ann Arbor, Michigan 48105

Dear Mr. Gray:

This is in reply to your October 31, 1979, request for further information. Although somewhat confused as to why you need some of this information in order to conduct tests, we hope that the following sufficiently answers your questions.

1. Applicability of the Device: The same basic unit covers all overhead valve push rod type engines used in automobiles and up to medium-size trucks.

   a. We have official approval from the patent office on another device which will cover all larger engines that use rocker arms to operate the exhaust and intake valves.

   b. We also have application to the Patent Office covering all other engine designs such as overhead cam and two cycle.

   c. Yes, four cycle push rod engines can use the device.

   d. Yes, vehicles without power steering can use the device by adding a steering pump or other hydraulic pressure source, such as a 12-volt pump unit.

   e. Yes, the same basic device will apply to rocker shaft type engines. The attachment to the engine varies but still can release the fulcrum point of the rocker lever.

f. We have successfully deactivated the following gasoline overhead valve, push rod type engines:

1. All six and eight cylinder Chevrolets,inc. V-6.
2. All six and eight cylinder Fords, inc. V-6.
3. All six and eight cylinder Chrysler products.
4. All six and eight cylinder Int. Harvester.

We have not completed prototypes on American Motors or any foreign vehicles. We see no reason to date to doubt that we can deactivate any overhead valve engine which uses push rods with this basic hydraulic unit. As mentioned, the attachment to the engine will vary, but we still accomplish the same result, that is, release of the fulcrum point of the rocker arm, allowing the engine valves to remain closed. Our capture of the lifters, be they solid, roller or conventional hydraulic, is covered by another patent application and present no problem.

2. Description of the Device:

a. We plan to market a device for every popular engine design known - as you know, descriptions of these would fill a book. However, there is one common function which will clarify this problem a great deal: We completely stop the air flow through the deactivated cylinder in all cases. In most engines we accomplish this by closing the valves, both intake and exhaust. In engines such as overhead cam engines and two cycle, we cannot control the valves so we must add a device to stop air flow both at intake and exhaust, still accomplishing the same result.

In diesel engines, since stopping air flow does not stop fuel, we further must effect a shut off of the injectors. We also have patent pending on devices to accomplish this, depending on type of fuel system.

b. As to control of these devices, we have leaned toward an inexpensive type control, such as a switch convenient to the operator; however, since the system is electric over hydraulic, automatic control presents no problems beyond current technology.

c. We now have systems ready to market which are totally manual. You cannot switch from mode to mode while vehicle is moving. You must physically adjust valves into deactivated or normal position. This takes approximately five minutes.

d. We also have systems ready to market with the hydraulic unit, which allows you to switch from mode to mode at operators command.

3. Device Installation: We are attaching information and trouble shooting instructions. Approximate time and cost of installation:

Manual system kit	Suggested Retail $99.95 Approx. two hour installation
Hydraulic system	Suggested Retail - Unannounced Approx. eight hours install.

4. Device Operation: No restrictions on use. The control valves are activated by the operator.

5. Device Maintenance:

a. Solid lifter settings - factory specifications.

b. Hydraulic lifters - set to .002 clearance on deactivated cylinders. Hydraulic lifters have not failed in any way with this revised setting. We recommend a valve adjustment period compatible with a solid lifter application. The reason we alter this adjustment on hydraulic lifters is to prevent a rough running condition on the deactivated to the activated mode momentarily while the hydraulic lifter self adjusts to zero clearance.

6. Effects on Vehicle Emissions (non-regulated):

a. None of the vehicle emissions equipment is altered. Does it not make sense if we can operate the vehicle on less fuel with all the standard emission equipment in tach and functioning properly, our over all emissions will be less? Regulated and non-regulated?

7. The AESI Test Results:

a. 1978 Ford T-Bird, VIN #8J87S124951, C.I.D. 400 engine, transmission A3, air-conditioned, power

steering, odometer reading at time of test 13,290 miles. The information you have in hand is the only testing performed on the T-Bird at AESI.

b. The vehicle was dyno-tuned at an outside tune-up facility. The Highway Fuel Economy Test numbers for the eight cylinder engine testing are compatible with the history previous to any modification. We do not have any rationale to explain this.

c. We have no Federal Test Procedure information.

d. There was no Hot Start LA-4 test on this vehicle.

e. The Cadillac referred to in the letter was a brand new car. We understand that a car not broken in does not constitute a reliable test. While the car did show gains in the tests conducted on it, they were not up to the standard of the gains that we had experienced on a wide variety of road testing, both city and highway. Under the above circumstances we do not desire to submit test data.

Since testing the vehicles at AESI, we have come to realize that due to the fact the tests were designed with the eight cylinder engine and all of the performance curves were based on the eight-cylinder power in relation to that particular vehicle, we cannot possibly receive a fair test under these conditions. We do not claim that the vehicle will perform on half its cylinders in any given situation as well as it does on full power. Our goal is to save fuel and we have found that people will modify their driving habits to accomplish this with the deactivated engine. We strongly feel that a modified test curve should be designed around the deactivated mode of the vehicle.

We have a significant list of vehicles that are performing their normal everyday functions and show the 48% increase to be a realistic figure. Please find enclosed some of our test data. One other factor we should mention is the free-wheeling effect or coasting ability of the vehicle due to the no-air pumping of the dead four cylinders. As you know, most dyno-testing cannot simulate down hill coasting.

We are also attaching a copy of our latest memo received from the White House.

Please advise when you can set up testing.

Sincerely,

Tom Rogers
President

TR/gb

INCREASE YOUR MILEAGE UP TO 48%

IN A MATTER OF MINUTES!

WITH OUR MECHANICAL ACD UNIT!

The purpose of this kit is to de-activate one-half of the engine. This is accomplished by releasing the fulcrum point of the rocker arm, thereby allowing the valves to stay closed on the de-activated cylinders.

The kit also provides means for attaching the pushrod to the hydraulic lifter and furnishes a spring which holds the pushrod and lifter assembly up and away from the cam shaft while de-activated.

In 1976 Led Brock, a full time master mechanic and inventor, wanted to reduce his automobile's gasoline consumption. A cylinder de-activator system seemed to be the answer. Mr. Brock has worked with several cylinder de-activator system designs before deciding that he could design and build a better one. It took 2½ years but he did it.

Led's own car, a 1977 Chevrolet El Camino, was his first test vehicle. The engine was a 350 cubic inch V-8 averaging 14.41 M.P.G. It had been driven for 5000+ miles under all driving conditions. He then installed his newly designed cylinder de-activator system and averaged 21.59 M.P.G. for the next 9,000+ miles under the same driving conditions.*

The device, now known as the **"ACD"**, is generating tremendous interest and response. It has been subsequently installed on many other vehicles including: 477 cubic inch Cadillac; 425 cubic inch Cadillac; 351 cubic inch Ford; 400 cubic inch Ford; 302 cubic inch Ford. These vehicles are being driven every day, under normal driving conditions, and are recording spectacular results.*

An outstanding feature of the **"ACD"** is that it can be easily installed on most four, six and eight cylinder combustion engines with a conventional type internal cam shaft, lifters and pushrod configuration. The **"ACD"** can be installed by most do-it-yourself mechanics with little effort.

CAN BE USED ON MOST 4-6 & 8 CYLINDER CARS!!**

*Actual test data is on file at ACDS inc.

**Four, six and eight cylinder combustion engines with a conventional type internal cam shaft, lifters and push rod configuration.

IT WORKS! NO MAJOR CHANGES TO YOUR CAR!

"SAVE TODAY...DRIVE TOMORROW"

FOR MORE INFORMATION CALL OR WRITE

© 1979 ACDS Inc.

ACDS INC™
RESEARCH & DEVELOPMENT

1440 HILL ST., EL CAJON, CA 92020 (714) 440-7585

© 1979 ACDS inc.

IT WORKS! NO MAJOR MECHANICAL CHANGES TO YOUR CAR!

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HOW IT WORKS:

The **"ACD"** is a simple hydraulic device that can be installed on any non-overhead cam engine. The device de-activates alternate cylinders which enables the engine to maintain smooth operation with one half of its cylinders not operating.

The **"ACD"** is activated by a manual switch located in a convenient position for the driver. Inasmuch as the **"ACD"** is an electro-hydraulic system, it is feasible to activate with an automatic accelerator switch.

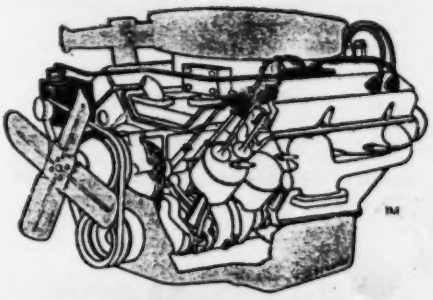
As the system is de-activated, the pressure is hydraulically released in the **"ACD"** causing the rocker arms, push rods and lifters on alternate cylinders to become disengaged. Simultaneously the valves are then left in the closed position which results in zero fuel consumption within that cylinder. The electrical system remains in full operation which allows the spark plugs to fire. However, after 40,000 test miles, there has been no damage to the engine as a result of this.

When the **"ACD"** is activated, the hydraulic system places the rocker arms, push rods and lifters back into service. The engine is now operating on all cylinders again.

The hydraulic fluid system works as a cushion against any damage to the engine or any of its internal working parts.

The transition is smooth and safe while taking less than one second to activate or de-activate the **"ACD"** fuel saving system.

CAN BE USED ON MOST 4-6 & 8 CYLINDER CARS!!**



*Actual test data is on file at

**Four, six and eight cylinder combustion engines with a conventional type internal cam shaft, lifters and push rod configuration.

"SAVE TODAY...DRIVE TOMORROW"

FOR MORE INFORMATION CALL OR WRITE

ACDS INC. TM
RESEARCH & DEVELOPMENT

1440 HILL ST., EL CAJON, CA 92020 (714) 440-7585